

Source Storage and Calibration Building

SCHLUMBERGER GUYANA INC.

SCHLUMBERGER GUYANA INC. | LOT 1, AREA X HOUSTON, EAST BANK DEMERARA.

Project Name

Source Storage and Calibration Building

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DEFINITIONS AND ACRONYMS

Term	Definition
SLB	Schlumberger Guyana Inc.
Facility	The location that stores, maintains, uses or is responsible for any source of ionizing radiation.
Restricted Area	A locked, enclosed area used for the storage of radioactive material that meets the security requirements for the type of radioactive material stored, the security status of the location in which it is installed and all applicable local regulations for such storage. Entry into Restricted Areas is restricted to Schlumberger Radiation workers. A Restricted Area can be at a permanent or temporary Schlumberger facility or at a wellsite.
Controlled Radiation Area	An area in which activities are performed with sources of radiation by SLB Radiation Workers and where specific protection measures and safety provisions are required for controlling normal exposures and preventing or limiting the extent of potential exposures.
Ionizing Radiation	Charged particles (alphas, betas, positrons, and protons), neutrons, gamma rays and x-rays capable of creating damage to human cells through the ionization of chemicals within the cell.
RSO	Radiation Safety Officer
ICRP	International Commission on Radiological Protection
IAEA	International Atomic Energy Agency. An organization within the United Nations family. Set up in 1957 as the world's center for cooperation in the nuclear field, the Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies
ANSI	American National Standards Institute: The American National Standards Institute is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.
Sievert (Sv)	It is a unit in the International System of Units intended to represent the stochastic health risk of ionizing radiation, which is defined as the probability of causing radiation-induced cancer and genetic damage.
Rem	Roentgen equivalent man is a unit used to estimate potential health effects of low levels of ionizing radiation on the human body.
ALARA	ALARA As Low As Reasonably Achievable. This term is used specifically for radiation risk reduction by the International Atomic Energy Agency and is equivalent to the principle of ALARP (As Low As Reasonably Practical).
RMIS-NG	The Schlumberger Corporate dashboard to monitor compliance of all radioactive sources, survey meters, radiation monitors, portable devices and HazMat keys. It takes the information from the corresponding Maintenance systems.
PACS	Physical Access Control System
GWI	Guyana Water Inc.
GPL	Guyana Power and Light
GTT	Guyana Telephone & Telegraph Company
EAMP	Environmental Assessment and Management Plan submitted to the EPA and accepted in January 2023.

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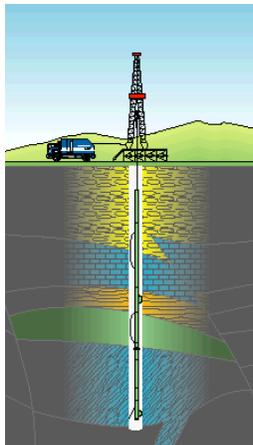
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1.0 PROJECT SITE DESCRIPTION

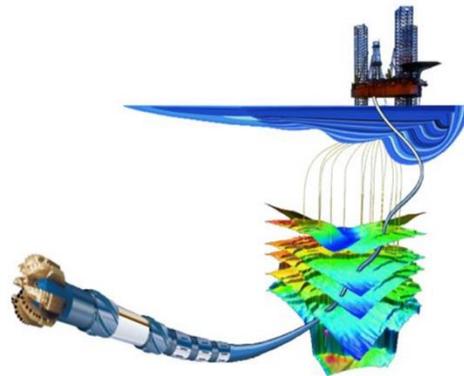
1.1 BACKGROUND

Schlumberger Guyana Inc. (SLB) is registered in the Co-operative Republic of Guyana to provide oil field services to the local oil and gas industry. Schlumberger Guyana Inc. provides upstream services with four primary areas of focus to include well construction, reservoir production systems, digital and integration and reservoir performance.

Radioactive sources are used in the oil and gas industry for well logging and well drilling. They are placed in tools that are lowered into the well, both on the drill string above the drilling bit during the drilling of the well (Well Construction) and on wireline lowered into the already drilled well (Reservoir Performance), in order to determine details of the formations passed through (lithology, porosity, fluid content, etc.). These measurements are of fundamental importance both during the drilling and afterwards to determine the success of the well.



Reservoir Performance Operations



Well Construction Operations

Figure 1. Schlumberger Operations using Radioactive Sources

The International Commission on Radiological Protection (ICRP) has set down the basic requirements for the use of ionizing radiation. These requirements, listed below, have been adopted worldwide as the basis for radiation protection.

1. No practice shall be adopted unless its introduction produces a net positive benefit.
2. All exposures shall be kept As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account.

3. The dose equivalent to individuals shall not exceed the limits defined by regulations.

The utilization of sources of ionizing radiation in well construction and reservoir evaluation operations, as practiced by Schlumberger, fulfills these three requirements fully. The net benefit is in the successful discovery and extraction of oil and gas, that would not be possible without the use of the measurements utilizing these sources of radiation. The doses received by our trained radiation workers, our untrained workforce that may be in the same facility or workplace and members of the public are strictly controlled through stringent operational procedures and control and mitigation methodology we employ, to ensure all doses meet the ALARA principle and are well within those limits defined by international regulations.

SLB invented the technology of lowering measuring instruments into wells to evaluate the presence of hydrocarbons. We have been operating with radioactive sources throughout the world since the early 1950's and have been in the forefront in assisting regulatory bodies such as the US Nuclear Regulatory Commission in the formulation of regulations and safe operating requirements for the use of ionizing radiation in Oil and Gas Exploration and Production.

SLB currently maintains licensed storage and calibration facilities in operating bases in many countries around the world including United States, Mexico, Venezuela, Trinidad, Brazil, Argentina, Colombia, and Ecuador, all located in the Western Hemisphere. These facilities are built considering the highest safety standard in the industry preventing any potential human or environmental risk. All have been approved and licensed by the relevant regulatory bodies in those countries.

A brief description of number of important facilities in the Western Hemisphere can be found in the **Appendix 1. Example of Operational bases with a source storage and calibration area (PIT).**

1.2 PROJECT JUSTIFICATION

In the initial phase of exploration for oil and gas offshore Guyana, Schlumberger operated remotely from an established base in Trinidad. However, it quickly became obvious, as the successful exploratory wells indicated very large commercial deposits, that a permanent base in Guyana to support these operations was essential. At the same time, Schlumberger decided that the importance of Guyana as a future regional leader in oil and gas production justified moving our regional Headquarters to Georgetown and to maximize the participation of the Guyanese economy and population in their operations.

The new regional Headquarters has been under development by Schlumberger over the last four years in what was previously the old Gafoors Houston Warehousing property and has been under development by Schlumberger over the last 4 years. The property now serves as Schlumberger's Regional Headquarters and Offshore Services Base, and which includes a Liquid Mud Plant, Dry Bulk Facility, and Workshop facilities to support the offshore drilling and production operations by the Esso Exploration and Production Guyana Limited (EEPGL) and other oil and gas operators.

As the above base was being developed, radioactive sources and the tools that utilized them, continued to be mobilized out of Trinidad. However, to completely integrate all Schlumberger's Guyana operations in a single facility, it is necessary to add a specific, secure building dedicated to (1) the safe storage of the radioactive sources used in our offshore operations and (2) to safely calibrate the tools that utilize these sources, within a single structure. This would minimize the movement of radioactive sources, that would only move outside the SLB Facility when transported on the limited access road to the berth and, from there, directly offshore on vessels. Thus the radioactive material would never be transported on the public roads of Georgetown.

1.3 FUNDAMENTALS OF RADIATION

Radioactivity is the spontaneous change in the arrangement of the protons and neutrons in a nucleus. Radioactivity results when the arrangement of the protons and neutrons in a nucleus is not stable. This spontaneous change in the arrangement of the protons and neutrons is referred to as radioactive decay. Radioactive decay results in the emission of ionizing radiation in the form of either particles or high-frequency electromagnetic radiation.

1.4 ELEMENTS OF DOSE REDUCTION

Three basic techniques can be used to reduce the dose received from a source of radiation: **time, distance and shielding.**

Time. The dose an individual receives from a source of radiation will reduce if more time is spent far from the source.

Distance. Ionizing radiation follows the inverse square law. If you double the distance from a source of radiation, then the dose rate is reduced by a factor of 4. This can be seen in the below Figure.

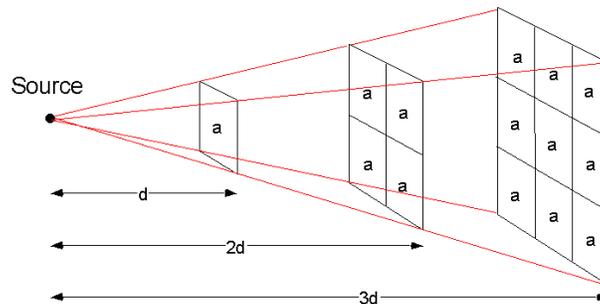


Figure 2 Inverse square law.

Shielding. Certain materials can weaken (or attenuate) ionizing radiation. The amount of attenuation depends on the specific material and its thickness. The ability of a material to attenuate ionizing radiation is expressed in terms of its half-value layer (HVL) thickness. HVL thickness is the thickness of material that will cut the dose rate in half. This is illustrated in Figure.

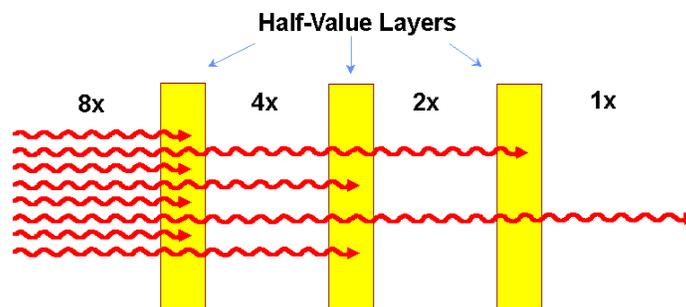


Figure 2.1 Shielding

1.5 CLASSIFICATION OF RADIOACTIVE SOURCES

Depending on the activity and nature of the different radioactive materials, the IAEA (International Atomic Energy Agency) has defined categories for source classification¹ based on the potential risk to People’s safety and security. These classifications are given in the table below:

Source Risk based on IAEA Sealed Source Categorization	
Source Category	Risk to People
1	Extremely dangerous to the person: This source, if not safely managed or securely protected, would be likely to cause permanent injury to a person who handled it or who was otherwise in contact with it for more than a few minutes. It would probably be fatal to be close to this amount of unshielded radioactive material for a period in the range of a few minutes to an hour
2	Very dangerous to the person: This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was otherwise in contact with it for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days
3	Dangerous to the person: This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was otherwise in contact with it for some hours. It could possibly — although it would be unlikely — be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks.
4	Unlikely to be dangerous to the person: It is very unlikely that anyone would be permanently injured by this source. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly — although it would be unlikely — temporarily injure someone who handled it or who was otherwise in contact with it for many hours, or who was close to it for a period of many weeks
5	Most unlikely to be dangerous to the person: No one could be permanently injured by this source

The Hazards of radioactive materials can be divided into two categories:

1. Radioactive contamination: this is where radioactive material is released and contaminated the ground, the air, buildings, and living organisms (insects, animals, humans). Such contamination will persist and require arduous mitigation efforts. However, because SLB only utilizes sealed sources in its operations in Guyana, this hazard can be considered de minimis. All radioactive sources are individually tested and certified by their manufacturer to meet the requirements of "sealed downhole sources" (i.e.ISO2919 or ANSI/HPS N43.6). They are triple encapsulated in steel, with the outer encapsulation of MP35 "Superalloy" that is considered the alloy most resistant to corrosion. All these sources are designed and tested to resist temperatures more than 450 F and 20,000 psi. All sources are tested annually for leakage. In the last 50 years of operating, no Schlumberger source has leaked in normal operations.

2. Irradiation (exposure to ionizing Radiation): Radioactive material emits radiation in the form of particles (alpha, beta) and High frequency electromagnetic radiation (X-rays, gamma rays). In addition, some sources can emit heavy particles called Neutrons. These particles and radiation can cause damage by ionizing atoms with which they collide. The radiation can be deposited as heat and, in living matter, cause damage to cells. Depending on the amount of radiation and the length of exposure, the harm caused will vary. However, SLB mostly uses Category 4 and 5 and small number of Category 3 sealed sources. All these sources are housed individually in dedicated transportation packages (shields). When shielded, the risk of any physical harm from radiation exposure is sufficiently low that these sources may be transported safely by road, sea or air. Sources removed from shields only momentarily within a Controlled Radiation Area (refer to definitions) by trained and authorized personnel following procedures that ensure the time the source is unshielded is the absolute minimum and that no unauthorized personnel are present when the source is unshielded. Considering distance and shielding this hazard can be considered de minimis for people outside of the Controlled Radiation area.

1.6 RADIOACTIVE SOURCES

Two examples of Schlumberger sealed sources and their shields are shown below.



Schlumberger has strict procedures for the storage, handling, transportation, utilization, and disposal of radioactive sources, with access to all such sources limited to trained and authorized personnel.

A full list of sources used in SLB operations are in the **Appendix 2. List of Sources** that Schlumberger can use in offshore operations.

1.7 STANDARDS

The Storage and calibration facility in Houston, Georgetown, was designed to meet our internal standards that meet or exceed the national regulations of the United States and the European Union that, in turn, follow the recommendations of International Atomic Energy Agency (IAEA). This facility was designed to ensure that exposure of members of the public is less than the regulatory limit of **1 mSv (100mrem)** per year.

SLB is fully aligned with the **IAEA Safety Standards** for protecting people and the environment, such as:

- **Safety Guide No. RS-G1.10.** Safety of Radiation Generators and Sealed Radioactive Sources.
- **Safety Guide No. GS-G-3.1** Application of the Management System for Facilities and Activities
- **General Safety Requirements Part 3.** Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
- **Specific Safety Requirements No. SSR-6 (Rev. 1).** Regulation for the Safe Transport of Radioactive Material.
- **Specific Safety Guide No. SSG-57.** Radiation Safety in Well Logging.

Source Storage and Calibration Building
Schlumberger Guyana Inc.

1.8 LOCATION

The Schlumberger Source Storage and Calibration Building is located at Lot 1, Area X Houston, East Bank Demerara. The location of the project area is shown in **Figure 3**.



Figure 3. Layout of Project Area

This property was previously the old Gafoors Houston Warehousing property and has been under development by Schlumberger over the last 4 years. The property now serves as Schlumberger's Offshore Services Base and includes a Liquid Mud Plant, Dry Bulk Facility, and Workshop facilities to support the offshore drilling and production operations by the Esso Exploration and Production Guyana Limited (EEPGL) and other oil and gas operators.

1.9 AREAS AND BOUNDARIES

The property is approximately 33,000 square meters total (63 meters x 480 meters). It is bordered by Guyana Shore Base (GYSBI) to the south, a private access road and private property (ECV owned) to the north, East Bank Public Road to the east, and the Demerara River to the west. A layout of property surroundings is shown in **Figure 4**.

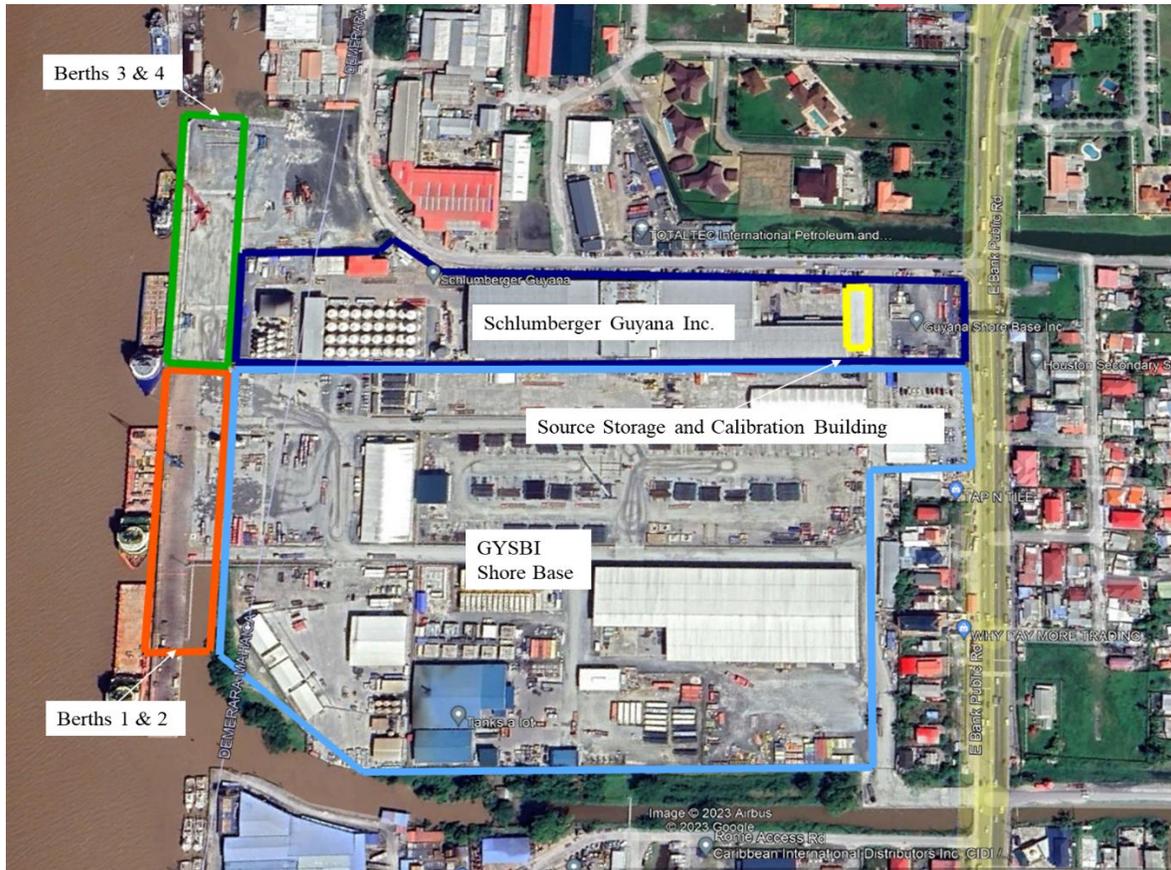


Figure 4. Layout of Property Surroundings

This specific project on the property requires approximately 450 square meters of land. The source storage and calibration building is 12.2 meters wide x 43.4 meters long. The location, shown highlighted in **Figures 5 & 6** below, is on the piece of open land just east of the new workshop expansion and just west of the new access road to GYSBI shore base.

Source Storage and Calibration Building
Schlumberger Guyana Inc.

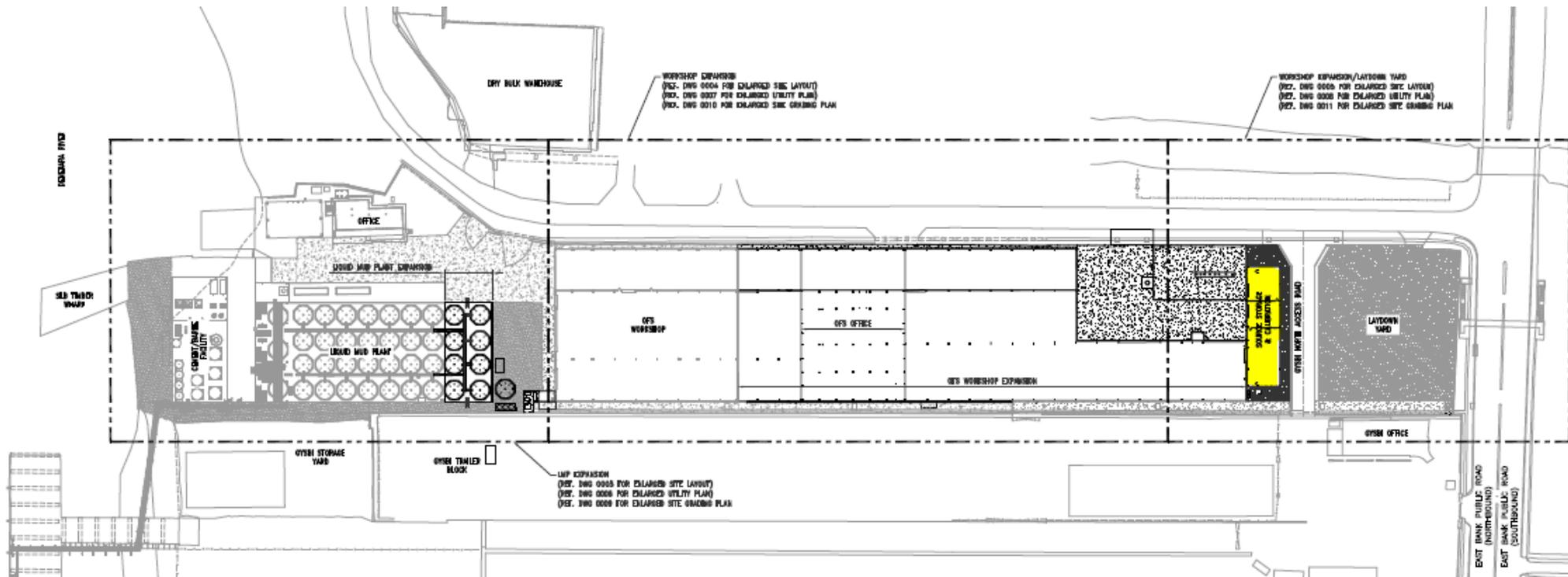


Figure 5: Overall Location of Source Storage and Calibration Building

Source
Schlur

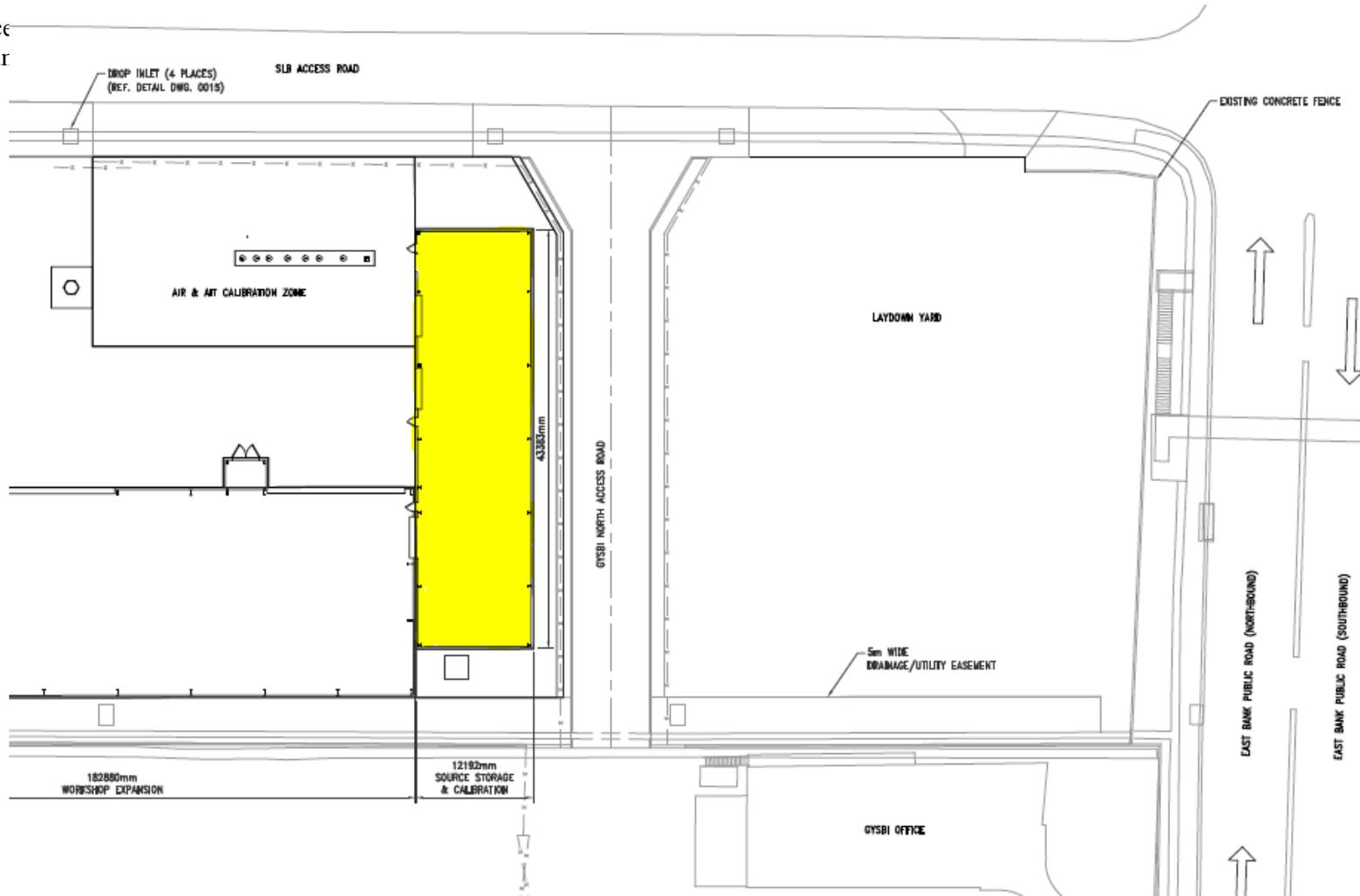


Figure 6: Enlarged Location of Source Storage and Calibration Building

Source Storage and Calibration Building
Schlumberger Guyana Inc.

1.10 RECEIVING WATERS AND POINTS OF DISCHARGE

The receiving water for the Schlumberger site is Guyana Water Inc (GWI). The roof structure of the Source Storage and Calibration Building is single sloped to the east. The rainwater will be collected in a gutter system along the east wall and be released in downspouts at each column line. The water will be released to the heavy-duty aggregate pavement and drain north or south. The high point of the pavement will be approximately at the center of the length of the building and half of the water will drain north into the private access road trench drain while the other half will drain south to the drainage/utility easement trench which runs the length of the Schlumberger property from East Bank Public Road to the Existing Workshop. The drains at both the north and south of the property drain to the east to meet up and tie-into the public drainage trench that runs the length of East Bank Public Road. At the points of tie-in to the East Bank Public Road drainage trench, the water then runs south to enter into McDoom Drainage Canal, which drains into the Demerara River. Figure 7 below shows the drainage for the project and surroundings.

Reference drawing 19364-02-0011 for detailed Enlarged Site Grading Plan for the Source Storage and Calibration Building.

1.11 FLOODING ANALYSIS

The radioactive storage pits within the storage and calibration building are situated 17m above Guyana datum. **Figure 8.** Source storage and calibration building foundation.

A topographic map of the area shows an altitude of 2m above sea level for the SLB facility. **Figure 9.** Houston Topographic map.

Guyana, because of the low level of much of the coastal plane, including the Houston community of Georgetown, is prone to flooding. An elevation map of the area shows that the Schlumberger facility is more elevated than its surroundings. In the event of flooding, there would be no risk from the radioactive sources. These are not only secured within locked pits, but the sources themselves are designed to withstand corrosive fluids at elevated temperatures (437 F) and pressures (20 000 psi), such that being submerged in floodwaters for extended periods would not impact their integrity. In the extreme case of severe weather events or tsunami of sufficient force to demolish the entire facility, the pits themselves would not be damaged and the risk of release of radioactive material would be non-existent.

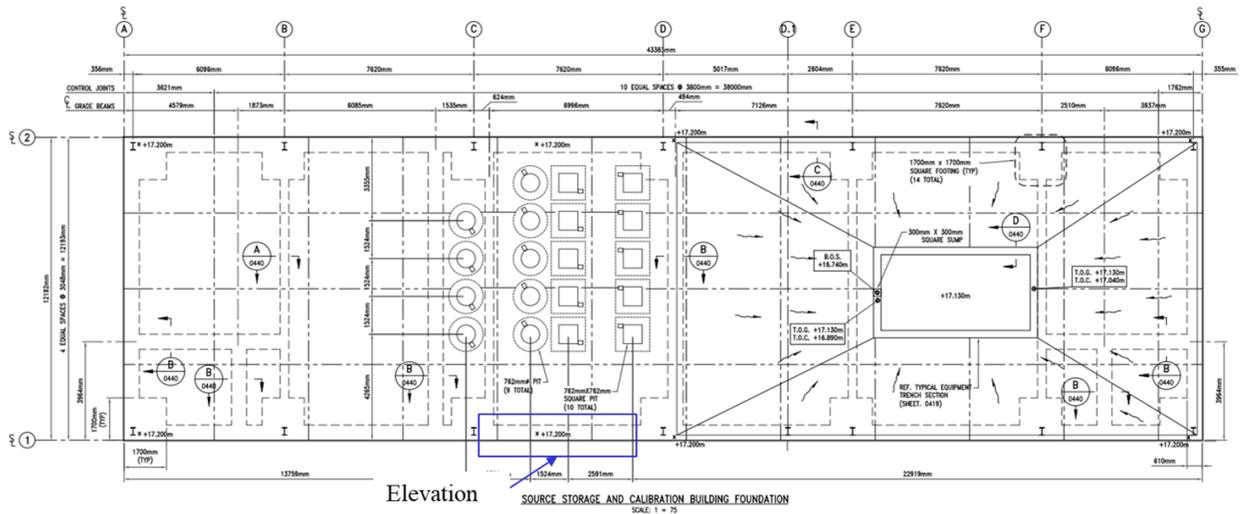


Figure 8. Source storage and calibration building foundation.



Figure 9. Houston Topographic map.

2.0 PROJECT DESIGN

2.1 CONSTRUCTION

The Source Storage and Calibration Building construction took place while other construction and operational activities were ongoing on the property. The office building construction began in January of 2021. The Office construction is located approximately 120 meters west of the proposed location for the Source Storage and Calibration Building. The workshop expansion just west of this project (located within the 120 meters between the Office and Source Storage and Calibration Building) was operational in the first quarter of 2021.

The source storage and calibration building are situated where SLB will receive incoming downhole tools and radioactive sources stored within their secure transportation packages (shields) returned from the rig and where the sources in their shields are immediately retrieved, moved to the Source Storage and Calibration Building and stored in underground pits. The downhole tools are then sent to the workshop where they are cleaned, repaired, inspected, and tested prior to being shipped back to the rig.

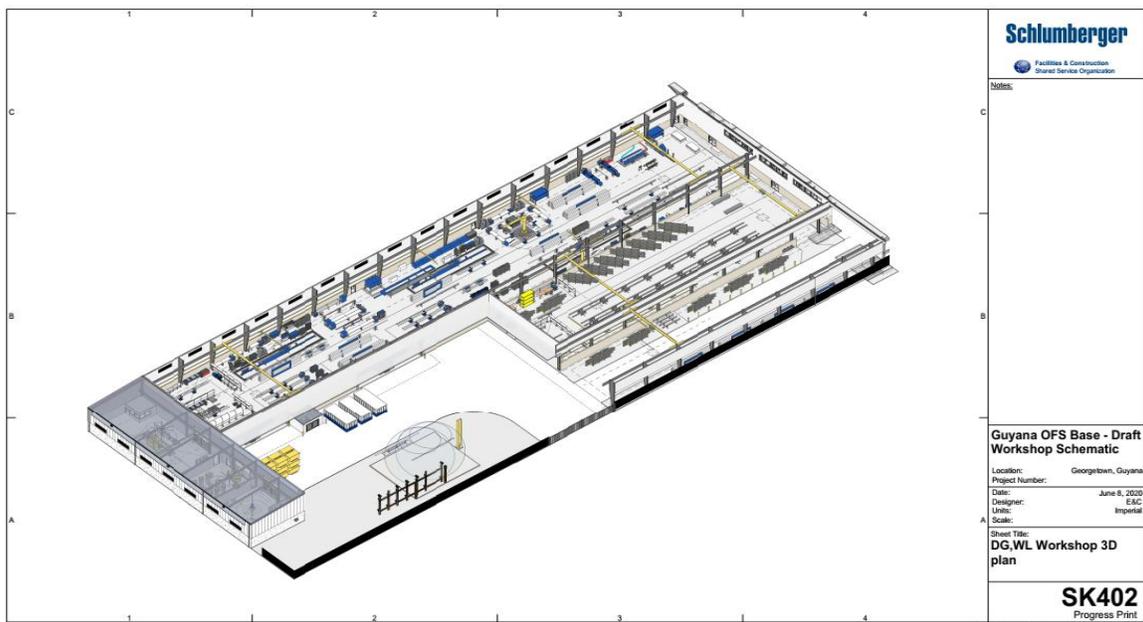


Figure 10: East Workshop and Source storage and Calibration Building

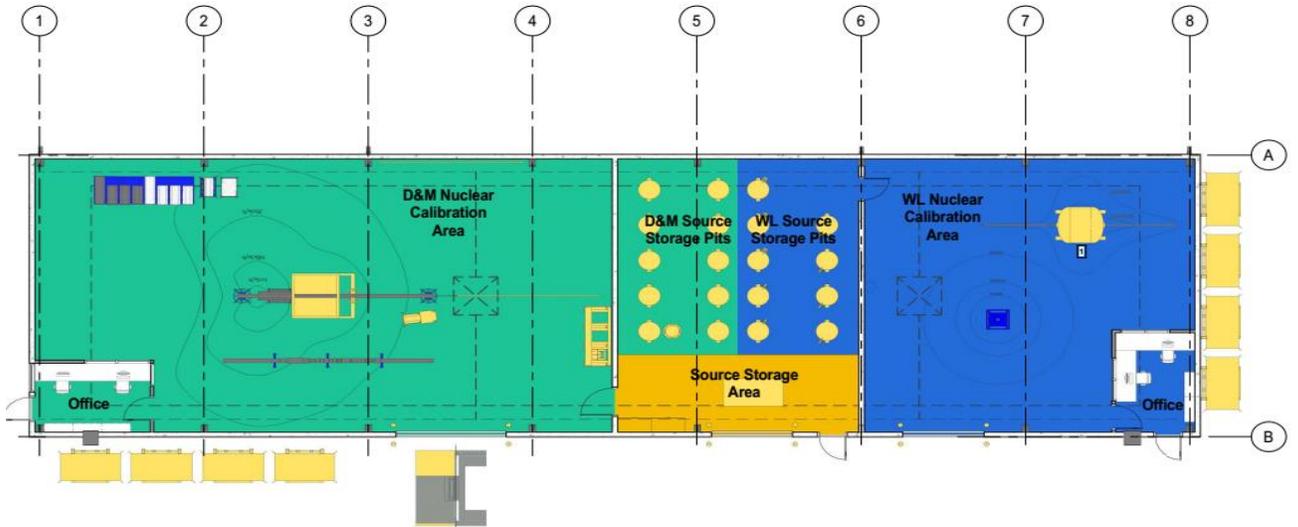


Figure 11: Proposed Source Storage and Calibration Building Plan

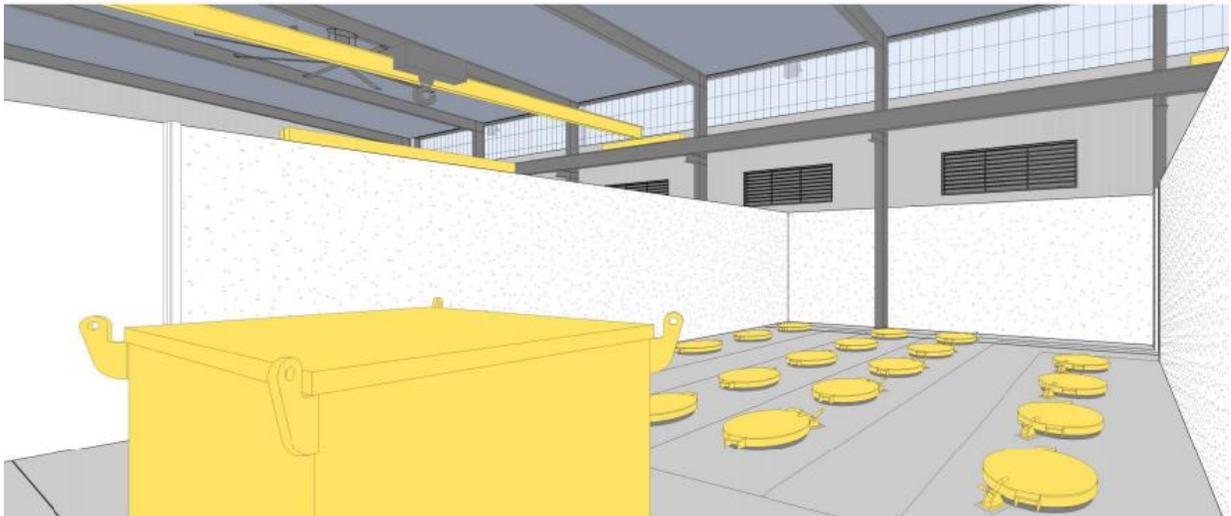


Figure 12: Source Storage Area (With Underground Pits)

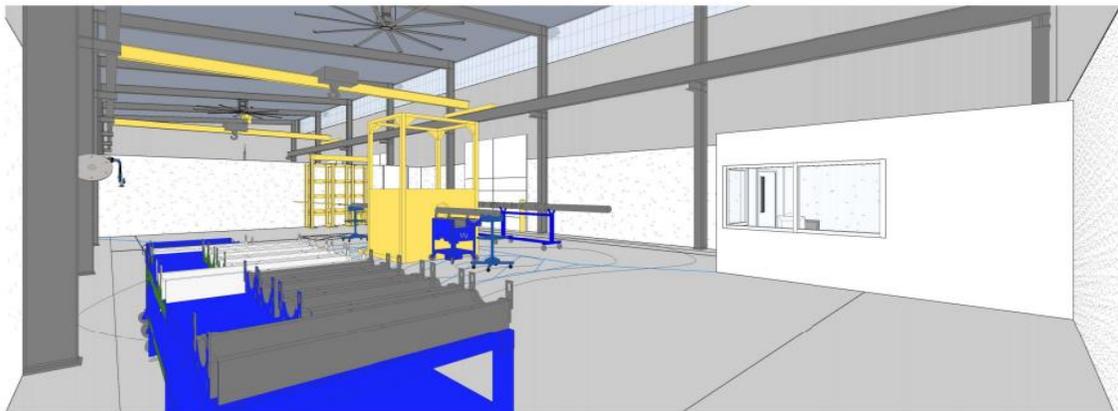


Figure 13: Drilling and Measurements Calibration

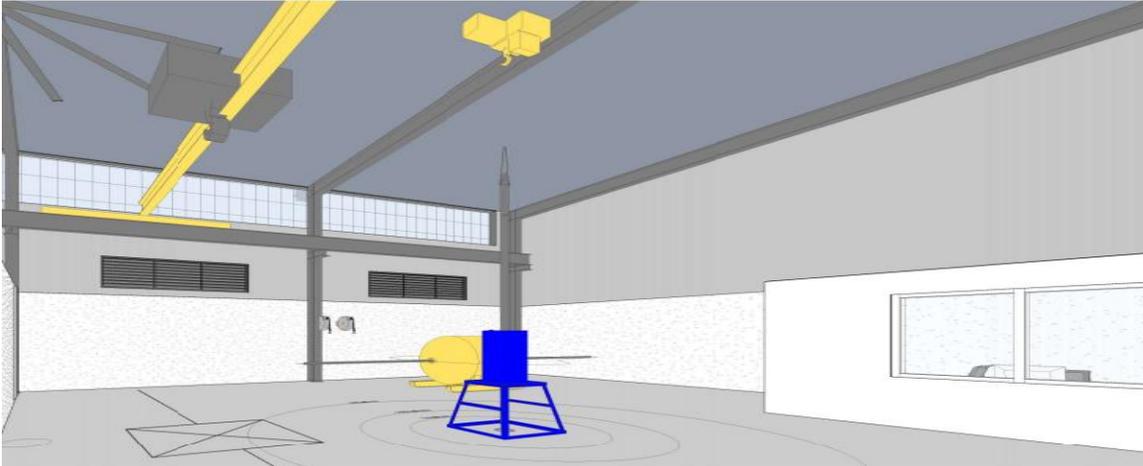


Figure 14: Area Wireline Calibration Area

The calibration operation requires the use of a radioactive source as well as overhead cranes and forklifts. All personnel involved in this operation are required to have proper training and certification specific to the location where the calibration will be performed. The Sources are stored inside a pit that has been designed to avoid exposure to the personnel and provide the security to unauthorized personnel to access it. For this project there are nine (9) circular pits and ten (10) square pits. The circular pits are 762mm diameter and 2.75m deep. The square pits are 762mm x 762mm square and 2.75m deep. The pits are constructed of 300mm thick reinforced concrete walls with a 300mm thick concrete base. They are lined with an interior shell made of 7mm thick carbon steel plate. Any movement of a radioactive source is clearly documented to keep the traceability of the status and location of radioactive source. Therefore, any movement of a radioactive source from the pit or to the pit is written and signed by the employee who performed the activity in Radioactive Control Book. An example of a radioactive pit where sources are stored is shown below in **Figure 15**. Radioactive pit.

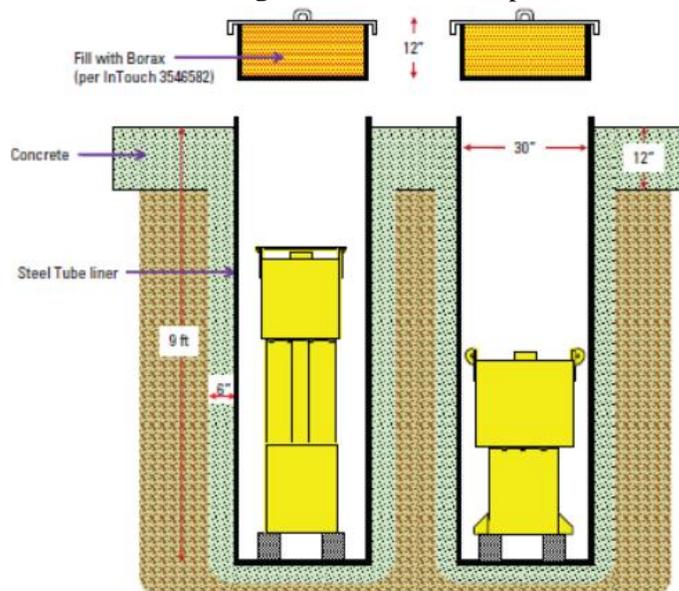


Figure 15: Radioactive pit

This a comparative chart of the IAEA Standard vs SLB Standard in the Radiation Safety for the storage of radioactive sources.

IAEA Radiation Safety in Well Logging SSG-57	SLB Standard-HSE-018-Radiation B.O.O.K
<p>11.27. If there is a need to store radioactive sources on a site overnight or between operations, they should be kept in tamper-proof sealed containers in an appropriate storage facility. The need for such storage should be identified in the planning phase, and arrangements should be made with the client for the provision of suitable storage facilities that comply with regulatory requirements.</p>	<p>4.5 All radioactive material shall be secured when at a Schlumberger facility, during transport or shipment and at well-sites and other temporary locations to prevent unauthorized removal. The security measures found in this section are in addition to any general security measures required for the facility either by Schlumberger Security Standard or local regulations.</p> <p>4.5.1 Security of radioactive material within its shield Each portable sealed logging source that is contained within a shield shall be locked within its shield (package) using a Business Line-specific HazMat lock. This lock and key shall be utilized exclusively for this purpose and no other. The HazMat key itself shall be subject to strict control in its acquisition and distribution. In addition to the highly controlled HazMat locks and keys, a secondary security such as a lock, with lesser controls shall be used to lock any overpack containing radioactive material packages.</p>
<p>11.28. On-site storage facilities should consist of a lockable room, or a purpose-built store or storage pit to which access is controlled. On-site storage facilities should provide the same level of protection and safety and security as storage facilities at the operating organization’s main base. A suitable storage facility should protect well logging equipment from the prevailing environmental conditions and should also provide an adequate level of safety. The storage facility should be weatherproof and resistant to fire.</p>	<p>4.8.6 Facility Operations with Radioactive Sources. All Facilities where radioactive sources are stored or utilized shall have the entire facility designated as an Access-Controlled Area. Within this Access-Controlled area, there are two principal zones: Unsupervised Area: In this area, there is no potential for exposure from the occupational use of ionizing radiation. No sources are ever present in this zone. Supervised Area: In this area, there is the potential for exposure to sources of ionizing radiation. This area would include the storage of tools containing radioactive sources (stabilization sources) or Neutron Generators (PNGs), maintenance workshops where tools containing radioactive sources (stabilization sources) or Neutron Generators (PNGs) are maintained, all source storage and areas where sources are utilized (e.g. master calibrations, leak tests, heat testing of tools with a source of radiation, etc.).</p>
<p>11.29. The storage facility should be built of materials that provide sufficient shielding to reduce dose rates outside the storage facility to levels specified by the regulatory body. The inside of the storage facility should be designated as a controlled area or supervised area, as appropriate.</p>	<p>D&M Appendix to the Radiation B.O.O.K. 1.10.2.1 Source Storage Design & Standard Source Storage Designs Underground storage should be adequate to contain all sources. Pits are built with Steel Tube liners, concrete and locked with covers filling with borax wich has shielding characteristics very similar to that of the Polycast it replaces, while it offers improved gamma-ray shielding characteristics. Borax is ecologically safe, chemically non-reactive, nonflammable, and is considered non-</p>

	<p>hazardous waste when spilled or disposed of. As a result, its hazard rating (NFPA 704) for health, fire, and reactivity are all minimal (zeros).</p>
<p>11.30. The door to the storage facility should be kept locked and the keys should be held only by authorized personnel. Keys should be of specific design that cannot be easily reproduced. A warning notice incorporating the radiation symbol [20] and emergency contact number should be displayed on the door. It is good practice to have two separate locks with different keys on the door to the storage facility, with the two keys being kept by different persons.</p>	<p>4.5.2 Security Requirements: Schlumberger Facilities</p> <p>4.5.2.2 Restricted Area. A Restricted Area is an enclosed area secured with at least a single lock and which is also enclosed in an Access-Controlled Area. A Restricted Area may be a locked cabinet; a locked room; a locked in-ground storage unit (e.g. pit) or a locked above-ground storage unit (e.g. overpack, rack with locking door, container). A Restricted Area shall have the following security:</p> <ul style="list-style-type: none"> •The lock used shall be unique to the facility •The keys to the lock used shall only be issued to Schlumberger personnel with a need for access to the material and shall be maintained under a Physical Access Control System (PACS). •The facility shall maintain a record of the personnel to whom keys for the restricted area have been issued. Hinges and hasps shall be attached to the doors or gates by welding, riveting or bolting (nuts on inside of door). They are to be installed in such a manner that the hinges and hasps cannot be removed when the doors or gates are closed and locked. •Restricted areas used to store radioactive materials shall be in a dry environment.
<p>11.31. On completion of the well logging work, workers should use a workplace monitoring instrument to confirm that each source has been placed into a shielded container and that no source has become detached. The results of this check should be recorded.</p>	<p>4.8.6.6 Movement of Sources out of and into Storage.</p> <p>When moving sources contained within their shields to and from storage for any purpose (including both shop and field operations), shields shall be surveyed using a calibrated Gamma Ray Survey meter to ensure the sources are present. This survey shall be documented in the facility's Radioactive Source Movements Control Book. This book will have a separate form for each source (Figure 4.8.7- 6). When the movement is to a well site, the surveys shall also be recorded in the Hazardous Materials Shipping Form (HazMat Form). These "in/out of storage" surveys shall be done in a position such that the survey meter reading is not influenced by other sources in storage. All other radioactive materials (calibration blankets, PNGs, stabilization sources, detectors containing stabilization sources) that are stored in Restricted Areas, shall also be subject to movement controls. Each such Restricted Area shall have a suitable movements form to maintain control of all movements out of and into the Restricted Area of all such radioactive materials.</p> <p>The Radioactive Source Movements Control Book, which may be located within the storage area or in a secure location along with the access keys to the storage area. All source movement records shall be retained for five years.</p>

	<p>4.8.7.8 Well-site Survey Procedures. Well-site surveys are performed in well logging operations to ensure that every source transfer between a source shield and logging tool is completed correctly and that the location of the source is known at all times. These surveys are mandatory (Schlumberger) and also may be a regulatory requirement. The surveys listed below are the minimum that shall be performed in operations where sources are removed from their shielding and placed into downhole tools at the well-site.</p>
<p>11.32. Before leaving the site, the workers should conduct a visual examination to ensure that equipment has not been damaged. Well logging tools housing radioactive sources should be made ready for transport by locking and securing the appropriate containers and transport packages. The transport package should be securely stowed in the vehicle to avoid damage during transport.</p>	<p>4.8.6.11 Pre-Job Preparation of Nuclear Equipment prior to dispatch to a wellsite. A visual inspection and inventory of all special field tools and accessory items shall be completed before leaving for the wellsite, using written inventory check sheets. Refer to the specific tool operations manuals, (PRM, TSM) and SWI's, or locally developed auxiliary box inventory lists. All essential measurement equipment, e.g. survey meters, mud monitoring equipment (where required), shall be present at the wellsite prior to initiating operations. Prior to dispatch, it is obligatory to inspect the source cavity of logging tools that are to be loaded with radioactive sources in the facility, to ensure it is in good condition and completely free from debris that might impede source loading. After every operation at the wellsite, the cavity shall be carefully flushed to remove any mud or debris. When the cavity is deemed clean, the cavity shall be closed or capped to prevent entry of debris before the next use.</p> <p>Surveys prior to departure from the rig site. Prior to leaving the wellsite, each source shield shall be surveyed to ensure that the source is present in its shield. These surveys shall be performed with sufficient distance between each shield such that the measurements made are directly related to the shield being surveyed and not affected by the proximity of another shielded source. If there is any doubt as to the presence of the source in the shield, it shall be opened to verify the presence of the source. If a shield is found to not contain the expected source, immediate action shall be taken to survey the logging tools, the rig floor and any other area where the source may have been accidentally left. When each shield has been verified to have its source in place, the shields shall immediately be secured for transport (in a logging truck compartment or shipping container/ overpack).</p>

2.2 TOOLS CALIBRATION OPERATIONS

Downhole tools are calibrated using known conditions. A typical calibration in facility takes 6-8 hours. The sealed source is never completely exposed, and it is only out of the storage shield for a brief period, typically about 5 minutes. During these operations, the area will be restricted to only the personnel directly calibrating the tools. The radiation level of the area is continuously monitored during the calibration and post calibration. **Figure 16** illustrates the set up for a Drilling and Measurement tool calibration.

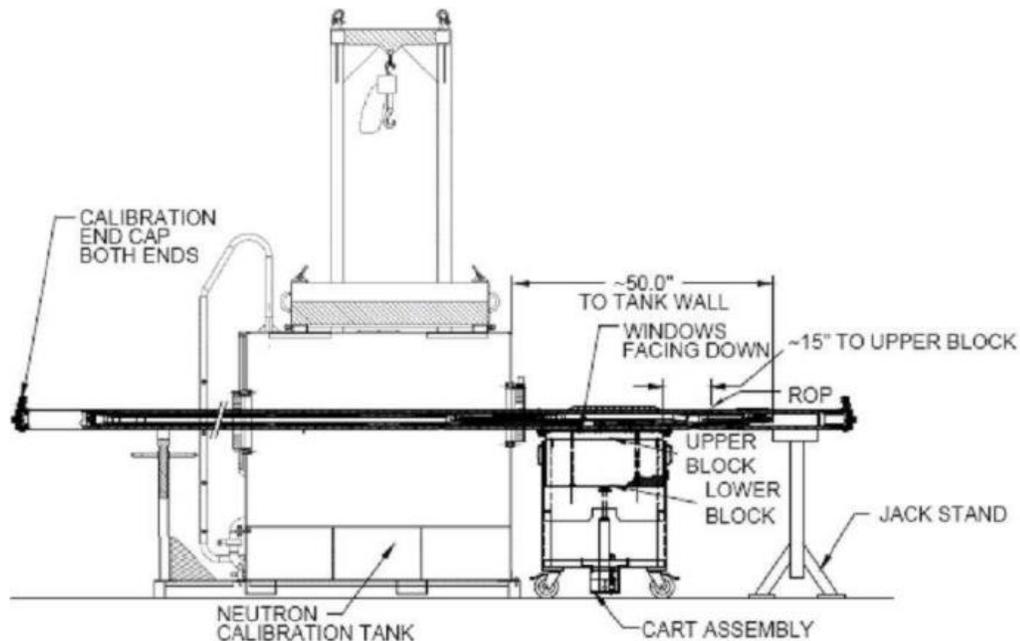


Figure 16. Drilling and Measurement Tool Calibration

The logging tools (LWD) used to support the offshore operations have sensors that need to be calibrated to confirm that the tools are working according to normal parameters. When the tool is in the calibration tank the RSO can confirm the radiation source is irradiating by physical checks through survey meters and then by using the downhole software in the control room, this software is connected to the tools using electronic cables. Water is used to simulate conditions that are well-known such as density and other correlations and also is used to shield the irradiation coming out from the tank. The radioactive material is never in contact with the water while performing these calibration operations. As mentioned in the section 1.5 our sources are tripled encapsulated with a superalloy that is tested and certified against strict standards.

The calibration period is different for each tool, ranging between 3-4 months as defined by SLB Standards.

Our monthly average is projected as per below:

Tool Type	Average Calibration Operations
Well Construction -ADN – LWD Tool	3 per Month
Well Construction - EcoScope – LWD Tool	1 per Month
Reservoir Performance - TLD Tool	1 per Month
Reservoir Performance - APS Tool	1 per Month
Reservoir Performance - Next Tool	1 per Month

*This average depends on field operations.

During the period of May to December 2022 a total of 39 calibrations were performed by the Radiation Safety Officers.

Appendix 3. List of Calibrations performed in the calibration building.

2.3 RESPONSIBILITIES

HSE Manager. The Location HSE Manager is responsible for advising and supporting line management to ensure that the protection of health, safety, and environment (HSE) remains an integral part of the business, and equal in priority to production and profitability. The Location HSE Manager serves as role model in applying HSE policies and standards in Schlumberger Guyana Base.

Facility Manager. The Facility Manager is responsible for planning and overseeing safe, secure, cost-effective, and environmentally-sound operations and maintenance of a large in the country. Aiming to preserve the long-term value of the assets. He ensures a consistent professional image for the facility or facilities. This person implements systems for tracking costs associated with facilities management. With line management, the Facility Manager develops and tracks specific site-base facility management key performance indicators, targeting cost reduction.

Regulatory Compliance Manager. The Regulatory Compliance Manager is responsible for managing and implementing the Schlumberger Regulatory Compliance Program for the location. The Regulatory Compliance Manager combines regulatory knowledge and technical HSE experience to ensure compliance with laws applicable to our business in Schlumberger Guyana Base.

Environmental Coordinator/Manager. The Environmental Manager owns the Environmental processes and practices within the country. They provide leadership in delivering effective implementation of Environmental processes. They measure Environmental performance through Key Performance Objectives monitoring and

reporting as well as monitor compliance to Environmental processes to enable continuous improvement.

HSE Specialist. The HSE Specialist is responsible for supporting local management in establishing and continuously improving Health, Safety and Environment (HSE) culture within the worksite.

Radiation Safety Officer. The Radiation Safety Officer is responsible for obtaining and maintaining all required licenses for the Country for Schlumberger's use, storage, shipment and/ or radioactive material and radiation generators. Review and ensure compliance with all regulations and procedures regarding the import and export, storage, transport and utilization of radioactive materials and radiation generators, as required by the applicable licenses and the internal standards. Maintain the country-specific training module for the on-site Radiation Safety Officers. Ensure that the Schlumberger Radiation Safety Program is properly implemented within the country. Provide emergency and technical assistance, as needed.

2.4 APPROVALS/PERMITS

In keeping with the City of Georgetown Building Regulations, permits were required for the execution of this Project. Schlumberger got the following permits:

Mayor & City Council

On 19th, March 2021. Schlumberger Guyana Inc. was granted by the city engineer's department to add a commercial storage facility as a storage and calibrating area for equipment. **Plan #347/2020**

Environmental Protection Agency

10th June 2021. Construction Permit. Reference No. 20200831-SOGSC. Schlumberger Guyana Inc. was issued by the EPA for the construction of a "Radioactive Source Storage and Calibration Facility at Lot 1 Area X, Houston, East Bank, Demerara, Georgetown, Guyana.

January 2022. Environmental Permit. Reference No. 20210714-XRFSG. Schlumberger Guyana Inc. was issued with an environmental authorisation by the EPA to operate a storage and maintenance facility for drilling tools maintenance. Activity: Possess, use, and store radioactive materials. Schlumberger Source/ Calibration Building at Lot 1 Area X, Houston, East Bank, Demerara, Georgetown, Guyana.

16th December 2022. After a court decision both permits were cancelled.

Central Housing & Planning Authority

22ND, April 2021. Schlumberger Guyana Inc. was approved by the **CHPA** to add a source storage and calibration facility for storage and installation of Radioactive Sources from Downhole Tools. **Application No. P-4VV/42/2021.**

2.5 SITE ACCESS

Site access for the Source Storage and Calibration Building is done via the entrance gate into the Schlumberger property off the access road bordering the north property line.

2.6 UTILITY SERVICES

- Electricity - Guyana Power and Light (GPL) is providing power to this transformer.
- Internet Access – This building is connected to the main router that the company uses to provide internet access to employee’s hardware.
- Water - Access water from Schlumberger’s water supply (Guyana Water Inc.)
- Security - Contractor is providing security for the facility.

2.7 SURVEY & CONSTRUCTION LAYOUT

All concrete in the proposed area for the building has been previously demolished and the existing grade is a sand/loam fill. The surveyor worked with the Project Engineer to establish a project benchmark and lay out the overall project. The Surveyor worked with the civil works contractor to establish and verify cut grades for any required soil removal. During backfilling to reach final subgrade elevation, the Surveyor set grade stakes and verified elevations for each compaction layer. Daily surveying and layout were done to allow for accurate excavation, shaping of fill material, and setting top of concrete elevations. The surveyor verified and recorded all final layers and verify top of concrete elevation once the concrete foundation was poured.

2.8 EXCAVATION

Soil excavations were performed for the column footings, grade beams, and the source storage pits. Excavation began using large bucket excavators to perform the main digging and small buckets or skid steers were used to obtain final depth. All excavated material was salvaged and reused by the contractor. A small generator driven sump pump was used to keep excavated pits free from standing water after rains. The surveyor confirmed all excavation depths.

2.9 STRUCTURAL BACKFILL

Approved structural backfill materials were brought in by trucks and dumped in the required area. The material was spread by a front-end loader or skid steer in lifts of no more than 300mm thickness prior to compaction. The surveyor confirmed all lift depths. Sand material was also soaked with the use of a water bowser to assist compaction. Once

compaction was completed, the Contractor engaged a qualified geotechnical engineering testing agency to perform compaction tests and inspections. Failed areas were cut, re-filled, and/or recompacted until the compaction criteria was met. Once compaction was verified, the next lift was placed. Upon completion of the structural backfill, final shaping was done by a motor grader. The surveyor confirmed all final subgrade elevations per the construction drawings.

2.10 CONCRETE FOUNDATION

Once the subbase was completed and compacted, installation of the concrete foundation commences. Prior to the concrete pour, the Contractor submitted a mix design to the Project Engineer for review and approval. The Project Engineer ensured the mix design meets all project technical specifications. The contractor built and installed formworks for the footings, pits, and exterior limits of the slab. The interior pit forms were made of steel (as shown on the construction detail drawings) and stay in place indefinitely. All other forms were built out of timber. While forms were built and installed, the Contractor built all steel reinforcing cages and mats as specified on the construction drawings and within technical specifications. Before installing the rebar, the contractor installed a thin concrete blind at the base of the slab and footings to avoid the rebar chairs sinking into the soil and keep the rebar mats at the specified elevations within the foundation.

Once the rebar and building precast anchor bolts were installed, the concrete foundation was poured. The concrete was placed evenly in layers and layers were compacted using concrete vibrators. Concrete was slump tested per the technical specification and trucks with failed slump tests were rejected. Concrete samples were taken every 76 cubic meters and tested per ASTM C 39/C 31M and the project specifications. Concrete slab was finished using vibration screeds, roller screeds, and bull floats. Saw-cut control joints were cut within 10 hours of concrete pour. The foundation was moisture cured and joints were prepared, cleaned, and filled with an approved joint filler. Forms were stripped and the concrete foundation works was complete.

2.11 METAL BUILDING ERECTION

Once concrete foundation was in place, the building erection commences. The contractor used a crane and manlifts to safely erect the metal building. The contractor began by erecting all columns, main beams, and x-bracing rods to ensure the structure was stable and prevent the columns from rocking. After the primary steel was installed and square, crane beams and rafters were installed. The two (2) 3-ton overhead traveling bridge cranes was installed before the roof purlins was installed. Once the bridge cranes with crane stops, crane rail, and bus bars were installed, the wall girts, purlins, and framed openings for doors were erected. Before installing the wall sheeting, the contractor formed up and pour the 8' tall concrete walls around the perimeter of the building as shown on the construction drawings. Once the exterior concrete walls were installed, the

contractor proceeded with installing the doors, wall sheeting panels, and roof sheeting panels. Finally, the contractor installed the finishing trim to complete the building installation.

2.12 TECHNICIAN OFFICE CONSTRUCTION

After the building was fully installed, the lab technician offices were constructed. The office walls were constructed of standard 8” CMU blocks. The ceilings were constructed of 3.5” metal studs and 5/8” thick gypsum board. After the block walls were installed, the office windows and doors were installed. Desks and miscellaneous furniture to complete the offices were installed later.

2.13 UTILITY INSTALLATION

The contractor installed light fixtures, receptacles, conduit, cable, wiring, and gear per the construction drawings to provide power to the building. This electrical installation included electrical connections to power the bus bar for the overhead bridge cranes. The power was provided from the 750kVA pad mount transformer serving the east workshop expansion. Guyana Power and Light (GPL) was providing power to this transformer. All electrical installations were inspected and tested per the project technical specifications.

The contractor installed all conduits and wiring for the telecommunications (including internet access, badge scanners, and security devices) for the building. Guyana Telephone & Telegraph Company (GTT) is the provider for telecommunications for this project.

The contractor tied into the existing 1” water line in the workshop and provided a water connection in the southernmost room of the calibration building containing a small trench. The water for the workshop ties into a 4” diameter main line which runs underground throughout the length of the south apron utility corridor (between the GYSBI fence and the Schlumberger new building construction). The Guyana Water Inc (GWI) meter for this water line is located at the southeast corner of the property just inside of the concrete fence bordering East Bank Road.

The contractor tied into the existing 1” compressed air line in the adjacent workshop and provide two (2) air outlets for use with small tools. The building electrical service (including workshop power) were backed up by a 500kW diesel powered generator.

Source Storage and Calibration Building
Schlumberger Guyana Inc.

3.0 PROJECT SIZE

The Source Storage and Calibration Building is 12.2 meters wide x 43.4 meters long.

Schlumberger Guyana has spent \$156,968,550 GYD (\$750,000 USD) for the construction of this specific project.

4.0 OPERATING DURATION AND DECOMMISSIONING

4.1 DURATION

Operations of this facility along with the workshop facilities is expected to be greater than 25 years.

4.2 ENVIRONMENTAL EXIT ASSESSMENT

If the business requires that the facility will be decommissioned. Schlumberger has an internal process to ensure that the exit process follows all legal requirements and international standards. These assessments comprise as a minimum an inspection of the site and a non-intrusive review of the site's history and possible environmental impacts. It comprises at minimum review of permit, license, monitoring and compliance reports. It includes review of public records and information sources, databases, aerial photographs, etc. A site tour will be executed which includes visual observation inside and outside any structures on the site and of the property boundaries and neighboring sites. A review of the surrounding area to identify and document environmental issues and potential stakeholder concerns including nuisance and potential off-site sources of contamination and areas of potential environmental or stakeholder (e.g., residential) sensitivity. This process is overseen by a professional with strong background in Environmental and Biological Sciences.

4.3 CLOSING A SCHLUMBERGER FACILITY

Any facility that will be sold (or, in the case of a leased facility, returned to the property owner) where Schlumberger has stored radioactive materials shall be surveyed to verify that the number of radioactive materials and radiation levels at the property are consistent with natural background levels. This survey will be conducted as follows:

- On a sketch of the property indicating the layout of the building(s) and all storage areas, set up a map grid representing 3m × 3m squares of the property.
- Measure the gamma-ray radiation over the entire property using a gamma radiation survey meter.
- Record at least one reading from this survey meter for each 3m × 3m square
- Record the serial number and calibration date of the survey meter. The person(s) conducting the survey shall sign and date the document.
- A copy of the survey record shall be maintained with other records for the closure of the property.
- A copy of the closure records shall be forwarded to the GeoUnit and the Global Radiation Safety Officer or Radiation SMA.
- When the results of all surveys indicate that there is no radioactive material or contamination in any part of the property, storage pits shall be filled in or removed, depending on the future use if the site and all radioactive signs removed before releasing the property.

5.0 WASTE MANAGEMENT

Solid Waste Generation

General domestic waste (plastic bags, paper wraps, and wood from covering and palletizing the tools) generate from this project is estimated below 300 kilograms. Industrial waste will be oily rags and other cleaning gear which will be about 150 kilograms per year. Wash rags and oily rags are stored in designated oily rag drums with automatic closing lids. Industrial waste is disposed through approved waste contractor companies. A waste management process is implemented to ensure that the solid waste is handled according to the regulations.

Water Uses

There will be one water connection in the calibration room in which there is a 300mm wide trench forming the shape of a 6.3m x 2.5m rectangle. This water is principally used to fill one of the calibration tanks. This trench is used as a secondary containment to block any water released from this tank. This trench would be cleaned by transferring directly from the trench to a 350-gallon tote with a diaphragm pump and hose and it would be sent to the recycling system that is fully equipped with proper filters which allow this water to be reused.

Appendix 4. Standard Operation Procedure for Water Usage in calibration operations.

Disposal

SLB sites dispose any source of ionizing radiation in accordance with applicable international and local regulations.

- Sources of ionizing radiation shall be returned to the appropriate company's Manufacturing center for disposal.
- In cases where sources of ionizing radiation were not acquired from a Manufacturing center, they shall be returned to the original manufacturer and country-of-origin for disposal.
- All other disposals require prior approval by the Subject Matter Expert (SME), being the Global Radiation Safety Officer (RSO)

Sources used in Guyana's Operation will be returned to the country of origin for disposal. No local disposals of radioactive materials will be executed within the country. The radioactive material used by SLB worldwide originated in the United States, and this material must be returned to the US at the end of its life.

The types of sources used in SLB operations will not generate any nuclear, hazardous or radioactive waste.

Preventive Measures in Radioactive Contamination.

All radioactive sources are individually tested and certified by their manufacturer to meet the requirements of "sealed downhole sources" (i.e. ISO2919 or ANSI/HPS N43.6). They are triple encapsulated in steel, with the outer encapsulation of MP35 "Superalloy". **Appendix 5.** MP35N: A Superalloy for critical Oil and Gas Applications. that is considered the alloy most resistant to corrosion. All these sources are designed and tested to resist temperatures of 437 deg F and 20,000 – 30 000 psi.

All sources are tested annually for leakage. In the last 50 years of operating, no Schlumberger source has leaked in normal operations.

6.0 ENVIRONMENTAL EFFECTS

6.1 PHYSICAL

6.1.1 LAND/SOIL

The sources used in our operations are classified as “Sealed Sources” and therefore do not pose any possibility of radioactive contamination.

The Houston, East Bank area is located on a narrow belt stretching along Guyana’s north-eastern coastline known as the Low Coastal Plain. As such, Houston is situated on low-lying, flat topography. The underlying soil is characterized as histosol, specifically a thionic gleysol of fine texture and low fertility. Textures are typically clay to clay loam (60% clay, 34% silt and 6% sand). The drainage for this soil type is rated as poor. The Project site has undergone prior development where it functioned as a warehouse for the Ghafoor’s Houston Complex

6.1.2 AIR

The activities within this facility will produce no odors and a minimum effect on air emissions. SLB has installed a backup generator to supply the Facility with electricity in the event of a failure of the local grid supplied through GPL.

Generator: Cummins 500kW
Manufacturing date: 05/17/2021
Model: DFEK-A066N893
Hours: 327.11hrs
Usage: standby only
Maintenance: scheduled every 250hrs
Generator enclosure: Sound attenuated enclosure
Installation Date: November 2021

See **Appendix 6**. Generator, Manufacturer’s specification sheet.



Figure 17. Diagram of emissions testing point around the facility.

Ambient Air quality monitoring was conducted December 2022 around the entire SLB facility. For this project summary, we considered the nearest testing point to the radiation building (**L02 Radiation Building Point**).

Report #	Date Sampled	CO	NO2	SO2
AQ/51308465/075	December 15, 2022	60.5	0	0

6.1.3 WATER

As all radioactive sources are sealed sources, and therefore no possibility of water contamination.

Water uses is described in the **section 5.0**, you can find the water use management process in the **Appendix 4**. Standard Operation Procedure for Water Usage in calibration operations.

6.1.4 NOISE

The Project will be well below ambient background noise levels and regulations and therefore will have no significant impact in the area.

The latest Ambient Noise Emission testing was conducted around the facility on December 2022, where the storage and calibration building is located.

Date Sampled	Report Number	dB
Thursday, December 15, 2022	NL/51308465/077	62.2

The impact of noise would generally be localized to the Project site and confined to the periods when machinery (overhead crane) is in operation. Noise generated by the operation of machinery would only influence workers. Operation of the project is expected to have minor impact on the surrounding environment after the implementation of mitigation measures.

6.2 **BIOLOGICAL**

6.2.1 **BIODIVERSITY**

Within the general project area there is limited biodiversity due to human interactions and development activities over the last years. The project site is entirely devoid of vegetation and in the wider project area most of the vegetation was also cleared to facilitate development, which includes housing, industrial and commercial activities.

There is some secondary vegetation along small sections of the roadway and on the banks of drainage channels comprising of secondary disturbed vegetation, primarily shrubs, herbaceous plants and several species of grasses. The dominant species include razor grass (*Paspalum virgatum*), antidesma (*Antidesma ghaesambilla*), carrion crow bush (*Senna alata*), morning glory (*Ipomoea hederifolia*), moko moko (*Montrichardia arborescence*) and tanner grass (*Brachiaria radicans*). These are all arable weeds and are quite common.

Aquatic vegetation in the drainage canals include: alligator eye (*Salvinia auriculata*), water lettuce (*Pistia stratiotes*), alligator spoon (*Eichhornia crassipes*), water poppy (*Hydrocleys nymphoides*), and the water grasses, *Paspalum repens* and *Luziola subintegra*. On the opposite bank of the Demerara River and on the same bank further up river there are some mangroves.

Fauna such as crickets (*Gryllus spp.*), butterflies, wasps, flies, beetles, and birds such as cattle egret (*Bubulcus ibis*), kiskadee (*Pitangus sulphuratus*), and yellow plantain (*Icterus nigrogularis*) are present in the general area. The drainage canals contain fishes such as hassar (*Hassar orestis*) and patwa (*Cichlasoma bimaculatum*). For the Demerara River, there is no documented information on the species found in the section of the River in the vicinity of the Project site.

There are no rare, threatened or endangered species on the Project sites and no protected area is located in close proximity. The Project will have little to no impact on coastal habitat or biodiversity. The Project will be in an existing industrial area with little to no habitat value for sensitive species. For these reasons, the Project will pose insignificant risks to biodiversity.

6.2.2 **ECOSYSTEM**

According to the research Annex A (3) Analytical Evidence to Support Guyana's Green State Development Strategy: Vision 2040 published by the Sustainable Management of Natural Resources Department the protected and conservation areas are defined in the **Figure 19**. Guyana Protected Areas.

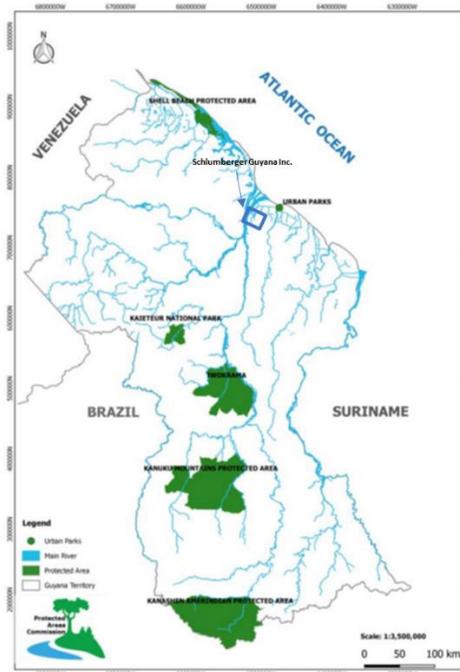


Figure 19. Guyana Protected Areas

The Project will not involve any direct disturbance of any coastal habitats, conservation or protected areas. Therefore, the Project will pose insignificant risks to ecosystem services provided by the nearshore marine ecosystem.

6.3 SOCIO-ECONOMIC

The socioeconomic effects for the surrounding areas where SLB facility including this building project were assessed as **positive**.

The overall SLB climate action strategy is underpinned by our commitment to achieve net-zero emissions by 2050 with interim targets for 2025 and 2030 along the way. Our goals cover all three scopes of emissions, and we are implementing a detailed road map of emissions reduction actions within each operating division and geography.

On sustainability, SLB’s vision is to define and drive high performance, sustainably. Balancing the opportunities and risks of energy transition and climate change. Protecting nature. Investing in our workforce and communities. Promoting diversity, equity, inclusion and respecting human rights. Schlumberger Guyana Inc. has aligned its corporate vision regarding Sustainability to the United Nation Sustainable Development Goals (SDGs) and Guyana’s Sustainable Plan. SLB is continuously committed to this through the following sustainable actions:

Employees

- By the end of 2022, the overall Local Content: 48.5%. Total workforce 511, Guyanese workforce 248.
- Roles occupied by Guyanese: Majority roles in Professional, Skilled & Semi-Skilled categories.
- Recruiting: Dedicated regional recruiting team focused on aggressive local headcount ramp up.
- All employees continue to benefit from varied on the job training throughout their career with us.
- Training: Hybrid training- virtual and overseas

Local Content Activities 2022

1. Recruiting Drives -Four initiatives held in 2022: UG Career Fair (March 25), Queen's College Career Day (May 27), Job Fair – Ministry of Labour (Nov 28) and Women in Technology Conference (Nov 16).
2. Education Collaborations - Several initiatives held in 2022: Technical Lecture to UG FET students (Apr 26), UG Distinguished Lecture Series (May 10), Queen's College Summer Math Institute (Jul 27), Resume Writing and Interview Skills Presentation (Oct 19 & 20), Open House and with UG Petroleum Engineering students (Nov 10 and 15).
3. Apprentice/Internship program for local candidates - 8 Guyanese interns engaged as at Dec 2022.
4. Rollout of Schlumberger's Excellence in Educational Development (SEED) program SEED initiative hosted with Houston Secondary School (May 20)
5. HSE initiatives – Youth and government / private agencies - HSE For Youth (May 19)
6. Environmental, Safety, Governance (ESG) Initiatives – Community engagements and donations: Laptop Donation - Houston Secondary (Feb 22), WCCIG - Guyana Women and Girl's Summit (23 March), Hauraruni's Children's Home Engagement (March 9), Art Williams - Sports Day (May 6), Inter-School Kayaking Competition
7. Vendor Growth Initiatives: Attendance at International Oil and Gas Conference (Feb 2022) and Region 3 Supplier Forum (November 2022)
8. Vendor Open House Days - 2 Vendor Open Days hosted attended by over 30 vendors.

Source Storage and Calibration Building
Schlumberger Guyana Inc.

Sustainability and other Initiatives

Our Sustainability spend in 2023 will support our main activities throughout the year: SEED initiative, Hackathon, Adopt-A-Beach and community donations. Other major projects on hand include planned donations for solar street lighting and investment in water treatment at our Guyana base.

7.0 MITIGATION MEASURES

7.1 IRRADIATION (EXPOSURE TO IONIZING RADIATION)

The sources are stored in shields that reduce their external radiation to a level that permits their handling by employees and transportation personnel. These, in turn, are locked within deep, shielded pits, that reduce the external radiation at the surface of the pit, to below the level permitted for continuous exposure or radiation workers (7.5 microsievert/hour).

These pits are situated in the building such that the radiation level at the perimeter of the building will be maintained below the regulatory limit of 1 mSv (100mrem) per year.

Environmental dosimeters will accumulate the radiation dose and will be assessed each quarter to ensure these limits are never surpassed. The only time sources are removed from the pits, besides for transport offshore, is for the calibration of logging tools. This is accomplished by placing the source(s) within the tool, that is placed within a calibration tank specific to that tool.

This will involve a momentary increase in the radiation level within the radiation storage and calibration area, but this will not be sufficient in strength or duration to increase the public dose above the permitted levels of accumulated dose or dose rate.

The calibration area is fitted with area radiation meters (measuring both gamma ray and neutron dose rates) to monitor that the dose rates during these operations are measured and controlled.

Safety guidelines for limiting dose are as follow:

- Ensure sources are maintained, locked, in their shields except when required for an operation (leak testing, calibrations).
- Use warning devices, such as meters with the audio function enabled, flashing strobe lights, signs, or barriers.
- Restrict or control access to the area surrounding tools and meters when they are calibrated. Only trained radiation workers shall be present during these activities.
- Ensure that all operations with radioactive materials are performed by Radiation Workers who are trained in the operation and following the relevant standard operation procedure.
- At all times, the correct handling tools shall be used when manipulating sources outside their shields.

- Prior to initiating any operation with unshielded sources, ensure that all auxiliary equipment to be used is in perfect working condition.
- At all times, implement time/distance in all procedures to ensure doses are ALARA.
- Rotate radiation workers.

7.2 RADIATION MONITORING

Schlumberger is continuously monitoring dust and noise generation as they already do for the existing workshop and drilling fluids facility. All equipment and machinery are properly maintained to specifications to minimize noise.

Ludlum Survey Meters will be used to monitor radiation around the building.



Figure 20: Ludlum Survey Meter

A Radiation Officer is assigned to this site. All personnel working with sources must wear a dosimeter badge which detects and measures exposure to radiation.

• Current type of SLB dosimeter is Landauer Luxel OSL:

Personal dosimeter	Control dosimeter	Area dosimeter
Radiation worker exposure	Background	Public exposure

- Dosimeters - regulatory requirement:
 - for the protection of the individual employee
 - for the protection of the company
- Local requirements – additional
- Wear period: 1 quarter (male) / 1 month (female)
- Return within **14 days** at the end of wear period together with Control dosimeter
- Report lost, forgotten or damaged badges to your Supervisor immediately to get replacement
- Dosimeter records must be retained for 10 years

• Can detect Beta, Gamma and X-ray, Neutron radiation

• Minimum detection level 1 mrem (GR)

Figure 21: Dosimeter Badge for Radiation Detection & Measurement

Radioactive emission testing was conducted at 24 test points about the Project’s fence line and main access road. Average radiation readings from the perimeter fence line and access road locations were noted to be **0.102 $\mu\text{Sv/h}$** . When calculated over 365 days, the cumulative radiation dose is **~876 $\mu\text{Sv/year}$** . This dose is below both the average global background levels and permit requirements for radiation. The average indoor radiation was calculated at **0.120 $\mu\text{Sv/h}$** . When the average background radiation measured from the perimeter fence line and main access road is subtracted from the average indoor radiation, net radiation from indoor equals **0.018 $\mu\text{Sv/h}$** or **157 $\mu\text{Sv/year}$** .

Please see the **Appendix 7**. Radiation Area Monitoring Report.

7.3 *RMIS-NG: RADIOACTIVE MATERIALS INVENTORY SYSTEM NEXT GENERATION*

RMIS-NG is a Tableau dashboard that is used to monitor and control all radioactive sources, survey meters, radiation monitors, and HazMat keys, by pulling the technical status information from the maintenance systems and calculate the compliance by Facility. It’s an important regulatory control mechanism and therefore its management is of high importance.

All movements, leak tests and inventories of all radioactive sources movements, and calibrations of meters and monitors shall be recorded in corresponding maintenance business systems used by Business Lines.

RMIS-NG is a digital tool used to monitor and control the following aspects:

- Inventory of Sources (Photo Inventory every 12 months and Confirmation Inventory every 3 months)
- Survey Meters
- HazMat Key Inventory
- Leak Test Certificate Validity

7.4 LEAK TEST

Schlumberger leak test requirements and frequency

Sealed sources shall be periodically tested to determine if the source is leaking. The frequency of leak test is listed in the table below and that required by local regulations.

Type of Source	Routine Period	Prior to International Shipment	Prior to Disposal (section 4.9)
Well-Logging Source	12 months	Within 6 months of projected arrival date	Within 3 months of projected shipping date
Sealed source used in calibration or function testing of logging tools	12 months	Within 6 months of projected arrival date	Within 3 months of projected shipping date
Energy Stabilization Sources for Well-Logging Detectors with an activity equal to or less than 3.7 MBq1	Exempt	Within 12 months of projected arrival date	Within 3 months of projected shipping date
Energy Stabilization Sources for Well-Logging Detectors with an activity greater than 3.7 MBq1	36 months	Within 12 months of projected arrival date	Within 3 months of projected shipping date
Sources contained within Surface Meters, densitometers, flowmeters	36 months	Within 12 months of projected arrival date	Within 3 months of projected shipping date
PNG (Neutron Generators, Minitrons)	Exempt	Within 12 months of projected arrival date	Within 3 months of projected shipping date

Leak test certificates (see Appendix 8) have a 12-month validity period for the leak tests of sealed source. For those countries where the regulation requires a leak test to be repeated within a shortest period, it is the responsibility of the Country RSO to ensure that compliance. If there is any doubt about the integrity of the source. A leak test shall be performed immediately.

Appendix 8. Example of Leak Test Certificate

Special Leak Test Requirements

A leak test shall be performed if there is any doubt as to the integrity of the source. A leak test is mandatory for the following:

- A source contained within a source transport shield or meter that is damaged during transport or use.
- A source contained within a source transport shield or meter that is damaged in a fire during storage, transport or use.
- A logging source that has been subjected to mechanical force to remove it from a logging tool.
- A wireline logging source or PNG recovered from the well following a fishing operation.
- An LWD logging source or PNG recovered from a stuck BHA on wireline or coiled tubing or recovered at surface from a tool that has been subjected to mechanical force exceeding the mechanical limits of the tool (excessive flow rates, circulation of corrosive fluids, or jarring) during stuck BHA.
- A PNG that is damaged and that might be ruptured: The PNG shall be removed from service pending the leak test result.
- Energy stabilization sources and radiation detectors with embedded sources must be leak tested immediately upon removal from a tool, collar or detector. This requirement applies to all energy stabilization sources regardless of activity, and to detector components such as crystals and neutron detector tubes that contain radioactive isotopes.

7.5 FLOODING MITIGATION PLAN

In case of a flooding event happening in the area where SLB is located these are the steps to be follow up to ensure that sources.

Mitigation Measures	Responsible
<p>Monitoring Phase. Weather Conditions Monitoring. During this initial step, HSE and RSOs will be monitoring the daily weather conditions around the base. A daily report will be published for internal acknowledgement.</p> <p>Use of the Hydrometeorological services of Ministry of Agriculture, Guyana.</p>	<p>HSE Manager & Security</p>
<p>Planning Phase During this phase the Emergency Response Team will be monitoring the decision of national entities to be aligned with the contingency plan of the country.</p> <ol style="list-style-type: none"> 1. SLB will follow all recommendations from authorities in the country. 2. Ensure that the facility has all resources available such as medical services, transport, radios, telephones, and communication protocol. 3. Keep an updated inventory of all assets and equipment that are within the base. A full inventory shall be made and verified with the company’s online Radioactive Materials Inventory System (RMIS) 4. Keep enough fuel storage for the electrical generators. 5. Clean up all waterways, remove any residue in water drains so water can flow non obstructed. 6. Personnel on board must be kept updated. 7. Logistic shall be ready with enough resources to mobilize any employee and equipment. 	<p>HSE Manager- Operation Manager</p>
<p>Response Phase</p> <p>The emergency response leader is the only person that will active the protocol based on the official notifications of government and other valuable sources of information.</p> <ol style="list-style-type: none"> 1. Keep constant communication with regulator and civil response agencies. 2. Perimeter Barriers. Protecting the property using appropriate barrier for main entrances that can help to keep the water out, including sandbag barriers. 3. Consider protecting individual areas and equipment by blocking windows, securing rack structures, create permanent barriers for critical equipment. 4. Proceed to shut down electrical equipment that is not considered critical for the business continuity. 	<p>Facility Staff – HSE Manager- Workshop Managers.</p>

<ol style="list-style-type: none"> 5. Raise key equipment above expected flood levels. 6. Move high value stocks and supplies to other location, get support from logistic department to arrange any transportation. 7. Flood Mitigation Pumps: Be ready with pump to remove the water that is within buildings, it will help to mitigate corrosion and mold. 8. Daily report to be shared with employees about contingency. <p>These actions will be followed up in conjunction with another support from civil authorities.</p>	
<p>Return Phase</p> <ol style="list-style-type: none"> 1. Emergency Response Team will ensure that the facility is safe to return by doing inspection in all areas around the compound. 2. Damage evaluation. Facility staff is in charge of estimate the potential of damages in the base. 3. In case of any damage to the building and structures, all repairs need to be done before employees can return to the offices. 4. When normal conditions are in place, employees and contractors will be notified by the line management to return to the normal duties. 5. All radioactive sources (within their shields) shall be removed from the pits and allowed to dry. Pits shall be pumped dry. All shields shall be given the necessary preventive maintenance to ensure the sources can be released from, returned to and secured. 6. Sources shall be inventoried to ensure records agree with pre-flood inventory in RMIS and then be returned to their storage pits. 	<p>HSE Manager and Facility Staff</p>

7.6 AIR QUALITY MITIGATION

The management of air quality is based on the identification of air, greenhouse gas and other related emissions. SLB has developed standard procedures and air monitoring program to mitigate the risks. SLB will implement measure to manage impact on air quality as listed below.

- Limit source point emissions by minimizing personal and heavy-duty vehicle idle time.
- Maintain engines and machinery in keeping with manufacturer recommendations to reduce CO, CO₂, NO_x and SO₂ emissions.
- Implementing preventive and corrective maintenance
- Use spark arrestors to minimize noxious emissions from diesel engines.
- Minimize the use of ozone-depleting substances to zero.
- Install engine emissions control of trucks and other heavy-duty vehicles.
- Install 'no idling' warning signage throughout traffic areas.
- Employ alternative measures where feasible when the provide a higher level of control for air emission.

Particulates

- Manage possible dust producing activities with suppression mechanisms.
- Ensure all dust-producing raw materials are fully covered and protected.
- Minimize vehicular traffic on unpaved roadways.
- Adhere to speed limits to reduce dust clouds.
- Seal unpaved roads with gravel bitumen or concrete.

7.7 NOISE MITIGATION

Schlumberger is continuously monitoring dust and noise generation as they already do for the existing facility. All equipment and machinery are properly maintained to specifications to minimize noise.

- Implement a Noise Monitoring Program around the building.
- Restrict operations where feasible to day-time hours between 07:00-19:00 hours.
- Restrict movement of heavy vehicles where feasible to daytime hours between 07:00-19:00.
- Install sound dampening devices such as silencers and mufflers on noise producing equipment.
- Place noise-producing equipment such as heavy-duty machinery, generators in the appropriate acoustic enclosure to minimize noise emissions.
- Ensure vehicles and machinery are maintain according to the manufacturer's recommendations to reduce mechanical vibrations and fault sounds.
- Ensure vehicle entryways and roadways remain unobstructed so as to minimize use of vehicle horns.
- Ensure personnel are provided with and comply with personal protection equipment (PPE) requirement.

7.8 FIRE PREVENTION

The facility has the following fire preventive measures:

- Fire extinguishers
- Smoke detectors
- Good housekeeping minimizes accumulations of flammable and combustible materials.
- Do not allow dirt and waste to accumulate in the area.
- Frequent cleaning to prevent build-up of combustible wastes and deposits, such as dusts from floors, ceilings, machinery and equipment.
- Walls and doors in good general condition

- Roof in good condition.
- Regular maintenance of rainwater drains (no leaves etc.)
- Permit to work system.
- Emergency Response Team with competences and knowledge in fire mitigation.

The radioactive sources are so placed in the pits that they will be protected from any normal fire. In addition, although rated 437 F, the sources will likely resist much higher temperatures. As an example, wireline sources were on board a drilling rig in the Gulf of Mexico subjected to an estimate of 1200 deg F, to the extent that the shielding of the sources was melted away. However, after recovery, the sources were sent to the manufacturer for testing and found to be undamaged, with no leakage of radioactive material. The risk of fire damaging our sources, such that there would be an increase of public irradiation is considered de minimis.

7.9 MOVEMENT OF RADIOACTIVE SOURCES (TRANSPORTATION).

The Schlumberger facility is placed ideally to service offshore operations, as it is directly placed beside the loading dock on the Demerara River. Movements of equipment, including radioactive materials from the Storage facility, are along a short roadway directly to the dock. No radioactive sources are removed from the facility into the Houston area. SLB is using a private road that goes directly from the SLB facility to the berths. In operations with radioactive materials, the highest risks, of loss or accidental exposure of the public, is precisely in their transportation. This risk to the local community is eliminated by having the source storage and calibration building, along with the storage of all other operational equipment, in this integrated facility with direct access to the vessel berth from which all equipment is transported to and from the offshore installations for drilling and extraction of hydrocarbons in operations with radioactive materials. This facility does not present any risk to the community.

When the movement is to a well site, the surveys shall also be recorded in the Hazardous Materials Shipping Form (HazMat Form). These “in/out of storage” surveys shall be done in a position such that the survey meter reading is not influenced by other sources in storage.

See Appendix 9. HazMat Form Example

Air Transportation

Radioactive sources may be transported by air in two scenarios; the first is when the source need to be sent for disposal, the second is when a new source is coming from manufacturers centers. SLB follows international standards such as IATA (International

Air Transport Association) Dangerous goods, which apply throughout the world for the movement of radioactive material and ICAA (International Civil Aviation Organization) Technical Instructions for the safe transport of dangerous goods by air which is the agency that formulates the basic requirements for air transport.

Safety Guidelines while shipping or transporting

- Place radioactive materials on the truck or vessel as far away as possible from the driver/passengers or vessel crew.
- Mark each radioactive material package or overpack with the words, “Caution Radioactive Material”.
- Ensure all packages presented for transport meet the regulatory requirements in terms of radiation dose and required marks and labels.
- Ensure, by performing a truck radiation survey, that the dose limits to truck occupants and the public are respected.
- Movement of sources out of and into storage shall be documented in the facility’s Radioactive Source Movements Control Book.
- Approved carriers for transport of radioactive materials.

There are no immediate plans to ship out or receive radiation sources by air.

See Appendix 10. Truck Transportation Survey

See Appendix 11. Source Movement Form-Control Book

7.10 RISKS ASSOCIATED WITH REMOTE LOCATIONS.

In contrast, having a separate facility of storage and calibration would increase the overall risk. This is due to the inherent risk of moving the radioactive sources using road transportation, which would be required to bring the sources from the remote facility to the berth for loading with other equipment for offshore operations.

Every such movement will require security arrangements to mitigate such risk. The risk of a traffic accident with the vehicle carrying radioactive sources may require the closing of the thoroughfare until specialized personnel could ensure the safety and security of the material and have it safely transported from the scene of the accident.

In addition, large trucks with trailers would be required to transport the large logging tools (up to 30 feet in length) from the Houston facility to the remote facility each time such equipment requires calibration. Any movement of heavy trucks therefore increases the risk, both to the public and SLB personnel.

7.11 EMERGENCY RESPONSE PLAN

This facility has prepared an **Emergency Management Plan** which cover emergency situations including:

- Leaking or ruptured source.
- Spill of radioactive material.
- Lost, missing, or stolen radioactive material (loss of control).
- Vehicle accident when the cargo includes radioactive material.
- Security incident involving ionizing radioactive sources, as appropriate to the security risk level of the area or country.
- Any dose of ionizing radiation exceeding the limits or action level.

You can find the procedures in detail in the **Appendix 12. Guyana Emergency Response Plans**.

8.0 SECURITY REQUIREMENTS FOR FACILITIES

All radioactive material shall be secured when at a Schlumberger facility, during transport or shipment, and at well-sites and other temporary locations to prevent unauthorized removal.

Security requirements are based on the **3D principle** of Deter, Detect, and Delay.

Deter – Physical and electronic security measures that provide a serious deterrent to intrusion.

Detect – Alarm Systems and CCTV to provide and verify detection of an attempted intrusion.

Delay – Physical security measures that delay the intruder for a sufficient length of time for a response force to arrive.

8.1 ACCESS CONTROLS

The facility has the following mandatory security systems:

- Fence or walls is at least 1.5 meters high, and have a deterrent to prevent climbing such as barbed wire, razor wire, etc.
- Security staff on duty 24/7.
- Entry of personnel and/or vehicles is limited by having doors and gates remain closed except when they are opened for entry by use of a Physical Access Control System (PACS) or verify by security staff.
- Vehicular gates are continuously monitored (24 hours per day/7 days per week) using video surveillance with camera resolution that allows the vehicle number and driver's identity to be verified.
- HazMat locks and keys are a primary security measure and control of access to radioactive logging sources.
- All HazMat keys are strictly controlled and inventoried in precisely the same way as radioactive sources:
 - Individually identified by type and serial number
 - Registered in RMIS (Radiation Monitoring Inventory System)
 - Inventoried every three months and photo inventoried every 12 months
 - Assigned to authorized individuals with training and security clearance to handle radioactive sources.

Access to the radiation Storage and Calibration Facility is limited to qualified personnel through swipe cards or keys. The facility is monitored 24 hours by both CCTV and sensors to detect any unauthorized entry.

The radioactive sources are secured in shielded, locked pits, that in themselves reduce the radiation level at the surface of the pit. Access to the pits requires two qualified employees, each with a different key, to unlock the pit lid. These keys are themselves secured in a box that can only be opened with the personal key of the RSO. In addition, an overhead crane must be used to lift off the pit lid and remove the sources. This crane also requires a qualified person to operate.

In all facilities, a safe system of work, such as a formal "Permit to Work", is in place to ensure that all activities where radioactive sources are removed from their shields (e.g. master calibration of logging tools or leak testing of sources) do not introduce a risk of exposing non-radiation workers or conflict with other operations. In addition, the permit to work shall ensure that the employee in charge is competent in the specific calibration operation and that all persons performing the calibrations have level 2 training. At all times, at least two persons shall be present during calibrations where sources are removed from their shields.

9.0 APPENDIXES

APENDIX 1. EXAMPLES OF OUR OPERATIONS IN OTHER COUNTRIES.

USA Midland

Schlumberger wireline and testing is positioned in an urban area. In the North is found the nearest neighborhood, less than 100 meters away from the facility. The nearest park and recreation area is in the west. You access to this facility using the main highway situated in the South. In the east face of the facility there are other services companies.



Mexico

Schlumberger Villahermosa is in an urban site named Rancheria Anacleto Canabal 3era. Seccion, Tabasco, Mexico. You can find at north a company that provides environmental services for the oil and gas industry, at south is located the main highway that connect the main city with other states. At east there are houses and local community and at west you can find an industrial park.



Source Storage and Calibration Building
Schlumberger Guyana Inc.

Venezuela

Schlumberger Venezuela “Las Morochas” is in Ciudad Ojeda City, Venezuela West. Around this facility there are neighborhoods, mall, hotels, parks, restaurants, and other natural areas that are less than 100 meters away from this facility. This facility has more than 50 years working and operating with sources without any event related to radiation.



APPENDIX 1.1. EXAMPLES OF SIMILAR OPERATIONS OF OTHER COMPANIES IN GUYANA.

There are similar operations by other major Oil and Gas Service providers that are in Guyana. One of them is located close to residential area, private companies, and shopping stores and close to the major road. Another is located at the Demerara east bank close by to private houses, businesses and borders the main road.

- They are operating under EPA permits Numbers 20180709-HSMPE and 20200923-RASBH.

APPENDIX 2. LIST OF SOURCES THAT SCHLUMBERGER CAN USE IN OFFSHORE OPERATIONS.

Well Construction Measurement

Nucleide	Activity	Form	Use	IF THE SOURCE IS ENCLOSED IN A DEVICE			Category
				Manufacturing	Model Number	Serial No.	
Cesium 137	63 GBq	Solid	Density Source EcoScope	QSA	GGLS-DA.	A2705	CAT 4
Cesium 137	63 GBq	Solid		QSA	GGLS-DA.	A2774	CAT 4
Cesium 137	63 GBq	Solid		QSA	GGLS-DA.	A2563	CAT 4
Cesium 137	63 GBq	Solid		QSA	GGLS-DA.	A2725	CAT 4
Cesium 137	63 GBq	Solid	Density Source SADN - AND	QSA	GSR-Z	A3100	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-Z	A2906	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-Z	A3222	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-Z	A3349	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-Z	A3415	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-ZC	A3134	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-ZC	A3289	CAT 4
Cesium 137	63 GBq	Solid		QSA	GSR-ZC	A3341	CAT 4
Americium 241/Be	0.00407 GBq	Solid		Neutron Source SADN - ADN	Gammatron	NSR-G	C1015
Americium 241/Be	278 GBq	Solid	QSA		NSR-T	Q1125	CAT 3
Americium 241/Be	278 GBq	Solid	QSA		NSR-T	Q1197	CAT 3
Americium 241/Be	278 GBq	Solid	QSA		NSR-T	Q1215	CAT 3
Americium 241/Be	278 GBq	Solid	Gammatron		NSR-T	H18	CAT 3
Americium 241/Be	370 GBq	Solid	QSA		NSR-U	Q1265	CAT 3
Americium 241/Be	370 GBq	Solid	QSA		NSR-U	Q1303	CAT 3
Americium 241/Be	370 GBq	Solid	Gammatron		NSR-U	U022	CAT 3
Americium 241/Be	370 GBq	Solid	Gammatron		NSR-U	U037	CAT 3
Tritium	55 GBq	Solid	PNG EcoScope		Schlumberger Technology Corporation	PNG-CB	8227-50860
Tritium	55 GBq	Solid		PNG-CB.		8789-51157	CAT 5
Tritium	55 GBq	Solid		PNG-CB.		8940-51812	CAT 5
Tritium	55 GBq	Solid		PNG-CB.		8986-52102	CAT 5
Tritium	55 GBq	Solid		PNG-CB.		8987-52104	CAT 5
Tritium	55 GBq	Solid		PNG-CB-R		8423-52052	CAT 5
Tritium	55 GBq	Solid		PNG-CB-R		8717-52058	CAT 5

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Tritium	55 GBq	Solid			PNG-CB-R	8718-52061	CAT 5
Tritium	55 GBq	Solid			PNG-CB-R	8860-52051	CAT 5
Tritium	55 GBq	Solid			PNG-CB-H	8636-51172	CAT 5
Tritium	55 GBq	Solid			PNG-CB-R	8752-51234	CAT 5
Tritium	55 GBq	Solid			PNG-CB-R	8861-50697	CAT 5
Tritium	55 GBq	Solid			PNG-CB-R	8866-50708	CAT 5
Thorium Natural 232	111 KBq	Solid	Gamma Ray Blanket	Schlumberger Tech	GSR-D	072-17	CAT 5
Cesium 137	33 KBq	Solid	Stabilization Source	Eckert & Ziegler	H343123	103427	CAT 5
Cesium 137	33 KBq	Solid			H343123	I4-898	CAT 5
Cesium 137	33 KBq	Solid			H343123	J9-398	CAT 5
Cesium 137	33 KBq	Solid			H343123	K3-547	CAT 5
Cesium 137	33 KBq	Solid			H343123	K4-469	CAT 5
Cesium 137	33 KBq	Solid			H343123	L1-542	CAT 5
Cesium 137	33 KBq	Solid			H343123	L1-733	CAT 5
Cesium 137	33 KBq	Solid			H343123	L2-475	CAT 5
Cesium 137	33 KBq	Solid			H343123	L5- 305	CAT 5
Cesium 137	33 KBq	Solid			H343123	L9-308	CAT 5
Cesium 137	33 KBq	Solid			H343123	M3-029	CAT 5
Cesium 137	33 KBq	Solid			H343123	N8-889	CAT 5
Cesium 137	33 KBq	Solid			H343123	P9-763	CAT 5
Cesium 137	33 KBq	Solid			H343123	R5-411	CAT 5
Cesium 137	33 KBq	Solid			H343123	S3-708	CAT 5
Cesium 137	37 KBq	Solid			H343123	K7-151	CAT 5
Cesium 137	33.3 KBq	Solid			H343123	M1-413	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	J3-005	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	L1-899	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	L9- 360	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	P6-309	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	R4-276	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	R5-585	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	R7-383	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	S6-048	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	S6-054	CAT 5
Cesium 137	33.3 KBq	Solid			H619737	T8-182	CAT 5

Note:	<p>Cesium Stabilization Sources in LWD Tools: Small Cs-137 sources are placed against the NaI crystals of the GR detector packages of the ADN, SADN and EcoScope (used in the Gamma-Gamma density measurement) to act as a gain stabilization reference sources for the spectral measurements of these tools. All Cs-137 stabilization sources can be shipped inside their detector package using the proper shipping name: UN2911, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - INSTRUMENTS, 7 - PNGs</p> <p>When any stabilization source is shipped by itself, the proper shipping name will be: UN2910, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL, 7. Both Schlumberger and US regulations exempt all sources of less than 3.7 Mbq (100 microcuries) from leak testing. However, some jurisdictions may have more stringent requirements. Each GeoUnit should verify the requirements for leak testing in the countries where they operate. In general, IATA regulations also exempt these sources from the requirement to leak test prior to shipment. this also may be different depending on the country of origin or arrival of the shipment.</p>

Reservoir Performance

Nucleide	Activity	Form	Use	IF THE SOURCE IS ENCLOSED IN A DEVICE		Category	
				Model Number	Serial No.		
Barium 133	370MBq	Solid	Phase Tester	BA133	GBA3.061.4.412.19	CAT 5	
Cs-137	7.4GBq	Solid	Special tubing and casing subs or collars for depth control	5192B	B6734	CAT 5	
Barium 133	37kBq	Solid		VZ-3433-001	Ba133-278-18	CAT 5	
Cesium 137	63GBq	Solid	Density Tool	GSR-J	A5668	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	A5666	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	A5451	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	4738	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	A5516	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	4802	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	A5537	CAT 4	
Cesium 137	63GBq	Solid		GSR-J	A5440	CAT 4	
Cesium 137	63GBq	Solid		GSR-Z	A3270	CAT 4	
Cesium 137	63GBq	Solid		GGLS-EZ	A3536	CAT 4	
Cesium 137	63GBq	Solid		GGLS-EZ	A3602	CAT 4	
Americium 241/Be	592GBq	Solid		Nuclear Tool	NSR-FC	G5075	CAT 3
Americium 241/Be	592GBq	Solid			NSR-F	2174	CAT 3
Americium 241/Be	592GBq	Solid	NSR-F		1191	CAT 3	
Americium 241/Be	592GBq	Solid	NSR-FC		G5081	CAT 3	
Americium 241/Be	592GBq	Solid	NSR-FC		G5271	CAT 3	
Americium 241/Be	592GBq	Solid	NSR-GB		4096	CAT 3	
Americium 241/Be	592GBq	Solid	NSR-FC		G5298	CAT 3	
Americium 241/Be	592GBq	Solid	NSR-FC		G5038	CAT 3	

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Americium 241/Be	592GBq	Solid	Gamma Ray Blanket	NSR-FC	G5315	CAT 3
Americium 241/Be	592GBq	Solid		NNSL-AFR	G5396	CAT 3
Thorium 232	55kBq	Solid		GSR-U	1089	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816202	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816203	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816204	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816205	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816206	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816207	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816208	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816209	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816210	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816211	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6220-07	CAT 4
Thorium 232	55kBq	Solid		GSR-U	1113	CAT 4
Thorium 232	55kBq	Solid		GSR-U	6816201	CAT 4
Thorium 232	55kBq	Solid		GSR-Y	077-39	CAT 4
Tritium	55.5GBq	Solid		Minitron PNG-(A/B/G/H/K)	PNG-HB	3093-51709
Tritium	55.5GBq	Solid	PNG-GC		7097-52208	CAT 5
Tritium	55.5GBq	Solid	PNG-BA		5175-51921	CAT 5
Tritium	55.5GBq	Solid	PNG-BA		5219-51388	CAT 5
Tritium	55.5GBq	Solid	PNG-BA		1046-52254	CAT 5
Tritium	55.5GBq	Solid	PNG-BA		5160-51037	CAT 5
Tritium	55.5GBq	Solid	PNG-GC		7053-52064	CAT 5
Tritium	55.5GBq	Solid	PNG-GC		7170-51719	CAT 5
Tritium	55.5GBq	Solid	PNG-GC		7028-51151	CAT 5
Tritium	55.5GBq	Solid	PNG-HB		3037-51275	CAT 5
Tritium	55.5GBq	Solid	PNG-AA		1169-7378	CAT 5
Tritium	55.5GBq	Solid	PNG-AA		1542-51088	CAT 5
Tritium	55.5GBq	Solid	PNG-GC		7168-51694	CAT 5
Sodium 22	.0925 kBq	Solid	Stabilization Source (HNGS tool)		HNGS-CA	220
Sodium 22	.0925 kBq	Solid		HNGS-CA	428	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	110	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	381	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	30	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	329	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	408	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	371	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	310	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-BA	112	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	171	CAT 5

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Sodium 22	.0925 kBq	Solid		HNGS-CA	119	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-CA	382	CAT 5
Sodium 22	.0925 kBq	Solid		HNGS-BA	204	CAT 5
Cesium 137	7.4 kBq	Solid	Stabilization Source (ECS Tool)	ECS-AA	65	CAT 5
Cesium 137	7.4 kBq	Solid		ECS-AA	128	CAT 5
Cesium 137	7.4 kBq	Solid		ECS-HP	3	CAT 5
Cesium 137	7.4 kBq	Solid		ECS-HP	8	CAT 5
Cesium 137	7.4 kBq	Solid		ECS-HP	15	CAT 5
Cesium 137	7.4 kBq	Solid		ECS-HP	5	CAT 5
Cesium 137	18.5 kBq	Solid	Stabilization Source (HLDT Tool)	HLDS-DA	53	CAT 5
Cesium 137	18.5 kBq	Solid		HLDS-DA	39	CAT 5
Cesium 137	18.5 kBq	Solid		HLDS-DA	41	CAT 5
Cesium 137	18.5 kBq	Solid		HLDS-DA	92	CAT 5
Cesium 137	18.5 kBq	Solid		HLDS-DA	64	CAT 5
Cesium 137	333 kBq	Solid	Stabilization Source (HRGD Tool)	HRGD-H	3930	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	4950	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	3933	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	5955	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	5854	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	5894	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	5841	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	5918	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				
Cesium 137	333 kBq	Solid		HRGD-H	4866	CAT 5
Cesium 137	22.2 kBq	Solid				
Cesium 137	351.5 kBq	Solid				

APPENDIX 3. LIST OF CALIBRATIONS PERFORMED IN THE CALIBRATION BUILDING.

Reservoir Performance

Equip Code	Serial No	PAU	WO_Status	Test_Desc	Tool Set	Type	Actual Start Date
APS-CA	88	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
APS-CA	225	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
PNG-BA	5160-51037	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
PNG-BA	5219-51388	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
APS-CA	225	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
PNG-BA	5160-51037	GYOF-WL10	Closed	Calibration	APS-CA-TOOL	MNT	06-Dec-22
HLDP-CA	84	GYOF-WL10	Closed	Calibration	HLDT-DA	MNT	08-Dec-22
HLDP-CA	40	GYOF-WL10	Closed	Calibration	HLDT-DA	MNT	07-Dec-22
HRGD-H	5894	GYOF-WL10	Closed	Calibration	HILT-TLD-H	MNT	24-Nov-22
HRGD-H	5841	GYOF-WL10	Closed	Calibration	HILT-TLD-H	MNT	24-Nov-22
NEXS-C	164	GYOF-WL10	Closed	Calibration	NEXT-C	MNT	22-Nov-22
NEXS-C	145	GYOF-WL10	Closed	Calibration	NEXT-C	MNT	22-Nov-22
NEXS-C	140	GYOF-WL10	Closed	Calibration	NEXT-C	MNT	22-Nov-22
HRGD-H	5894	GYOF-WL10	Closed	Calibration	HILT-TLD-H	MNT	21-Sep-22
HRGD-H	5841	GYOF-WL10	Closed	Calibration	HILT-TLD-H	MNT	20-Sep-22
HLDP-CA	40	GYOF-WL10	Closed	Calibration	HLDT-DA	MNT	18-Sep-22
HLDP-CA	84	GYOF-WL10	Closed	Calibration	HLDT-DA	MNT	04-Sep-22
HRGD-H	3933	SROF-WL10	Closed	Calibration	HILT-TLD-H	MNT	23-Aug-22
HRGD-H	3933	SROF-WL10	Closed	Calibration	HILT-TLD-H	MNT	23-Aug-22
HRGD-H	5841	GYOF-WL10	Closed	Calibration	HILT-TLD-H	MNT	04-Aug-22

Well Construction

Task Performed	LWD Type	Collar/ Chassis	Date	Success	Source	PNG
Full Calibration	EcoScope	3099 /2827	10-Dec-22	Pass	A2705	8717-52058
Full Calibration	EcoScope	3150 / 2931	7-Dec-22	Pass	A2705	8860-52051
Full Calibration	ADN8	H4019 / SN148	3-Dec-02	Pass	A3341 / Q1303	N/A
Full Calibration	ADN8	E6255 / 002	2-Dec-22	Pass	A3341 / Q1303	N/A
Full Calibration	SADN	42743 / 114	1-Dec-22	Pass	A3415 /Q1215	N/A
Full Calibration	SADN	DA520 / 274	30-Nov-22	Pass	A3222 /Q1125	N/A
Full Calibration	SADN	42743 / 114	14-Nov-22	Pass	A3415 /Q1215	N/A
Full Calibration	SADN	52005 / 8006	10-Nov-22	Pass	A3349 / Q1197	N/A
Full Calibration	SADN	52005 / 8006	22-Oct-22	Pass	A3349 / Q1197	N/A
Full Calibration	SADN	50221 / 229	29-Sep-22	Pass	A3349 / Q1197	N/A

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Full Calibration	SADN	13958 / 121	18-Sep-22	Pass	A3415 /Q1215	N/A
Full Calibration	SADN	50040 / 231	13-Sep-22	Pass	A3415 /Q1215	N/A
Full Calibration	EcoScope	3150 / 2931	9-Sep-22	Pass	A2705	8860-52051
Full Calibration	SADN	DA520 / 274	19-Aug-22	Pass	A3222 /Q1125	N/A
Full Calibration	SADN	50221 / 229	19-Aug-22	Pass	A3222 /Q1125	N/A
Full Calibration	SADN	50221 / 229	19-Jul-22	Pass	A3222 /Q1125	N/A
Full Calibration	SADN	50040 / 231	10-Jul-22	Pass	A3222 /Q1125	N/A
Full Calibration	SADN	52004 / 8006	24-May-22	Pass	A3415 /Q1215	N/A
Full Calibration	SADN	DA520 / 274	22-May-22	Pass	A3415 /Q1215	N/A

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**APPENDIX 4. STANDARD OPERATION PROCEDURE FOR WATER USAGE IN
CALIBRATION OPERATIONS.**



Written By: Ciro Ramirez/Maximiliano Zurita	SCHLUMBERGER GUYANA INC. WATER MANAGEMENT TOOLS CALIBRATION	Number & Rev. Level (Rev. Date): 0.0
Revised By: Maximiliano Zurita		Original Issuer Date: March, 2021
Approved By: Yuri Mozhaev		Pages: 1 of 5

1.0 Scope

This procedure is to standardize the water use in the tools calibration operation.

2.0 Objective

- Establish a proper water use in the tools calibration operation.
- Comply with local regulations.

3.0 Responsibilities

GeoUnit Legal Counsel

- Support interpretation of local requirements.
- Support interpretation and compliance with licensing requirements

Radiation Safety Officer

This RSO shall ensure full compliance with Schlumberger procedures and all applicable regulations and shall do the following:

- Obtain and maintain all required licenses for the Country for Schlumberger's use, storage, shipment and/or radioactive material (radioactive sources) and radiation generators.
- Review and ensure compliance with all regulations and procedures regarding the import and export, storage, transport and utilization of radioactive materials and radiation generators, as required by the applicable licenses and the B.O.O.K.
- Develop and maintain any country-specific addenda to the Schlumberger Radiation Safety Program as needed to meet specific local regulations and recorded in the CROG.

Facility Business Line PSD Manager and TLM Manager

- Develop and implement the worksite-specific controls required.
- Ensure all employees are trained in accordance with this standard, the B.O.O.K. and applicable Business Line and regulatory requirements.
- Ensure that a self-assessment audit of the site with responsibility for sources of ionizing radiation is completed at least every.

4.0 Regulatory Framework

IAEA. International Atomic Energy Agency. An organization within the United Nations family. Set up in 1957 as the world's center for cooperation in the nuclear field, the Agency works with its Member States and multiple partners worldwide to promote the safe, secure, and peaceful use of nuclear technologies.

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5.0 Overview

Shielding

Certain materials have the ability to weaken (or attenuate) ionizing radiation. The amount of attenuation depends on the specific material and its thickness. The ability of a material to attenuate ionizing radiation is expressed in terms of its half-value layer (HVL) thickness. HVL thickness is the thickness of material that will cut the dose rate in half. This is illustrated in Figure 1.

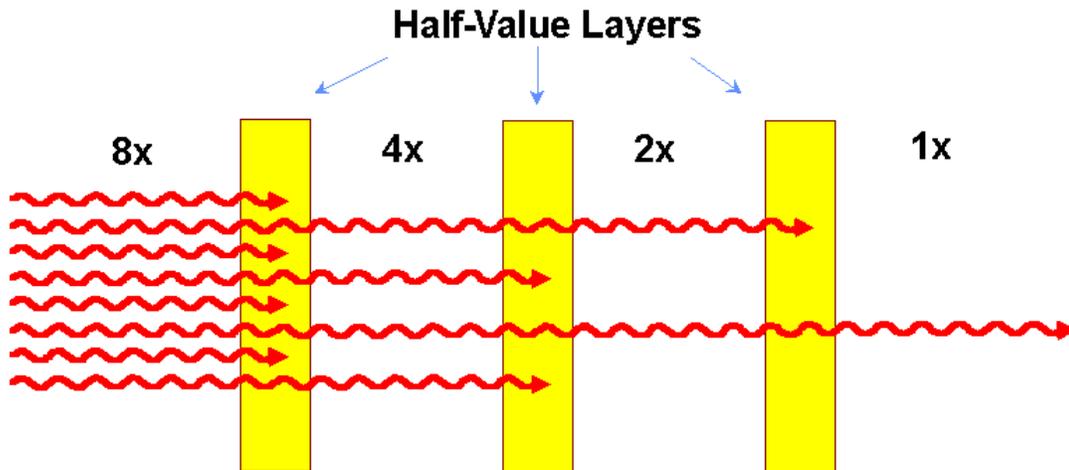


Figure1: Shielding

Water density is used in calibration activities as shielding to attenuate the gamma ray and neutron radiation emissions.

As it demonstrates in the Figure 2. Water is the most effective element to attenuate the ionizing radiation.

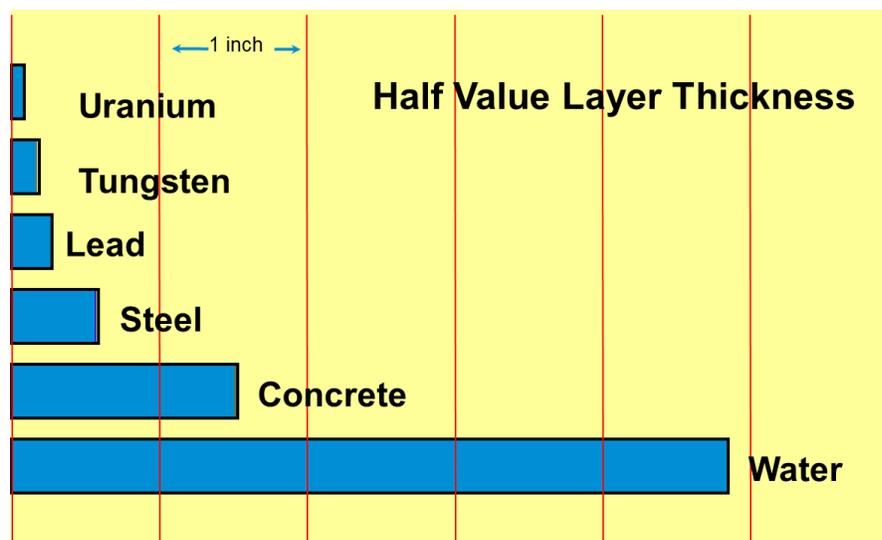
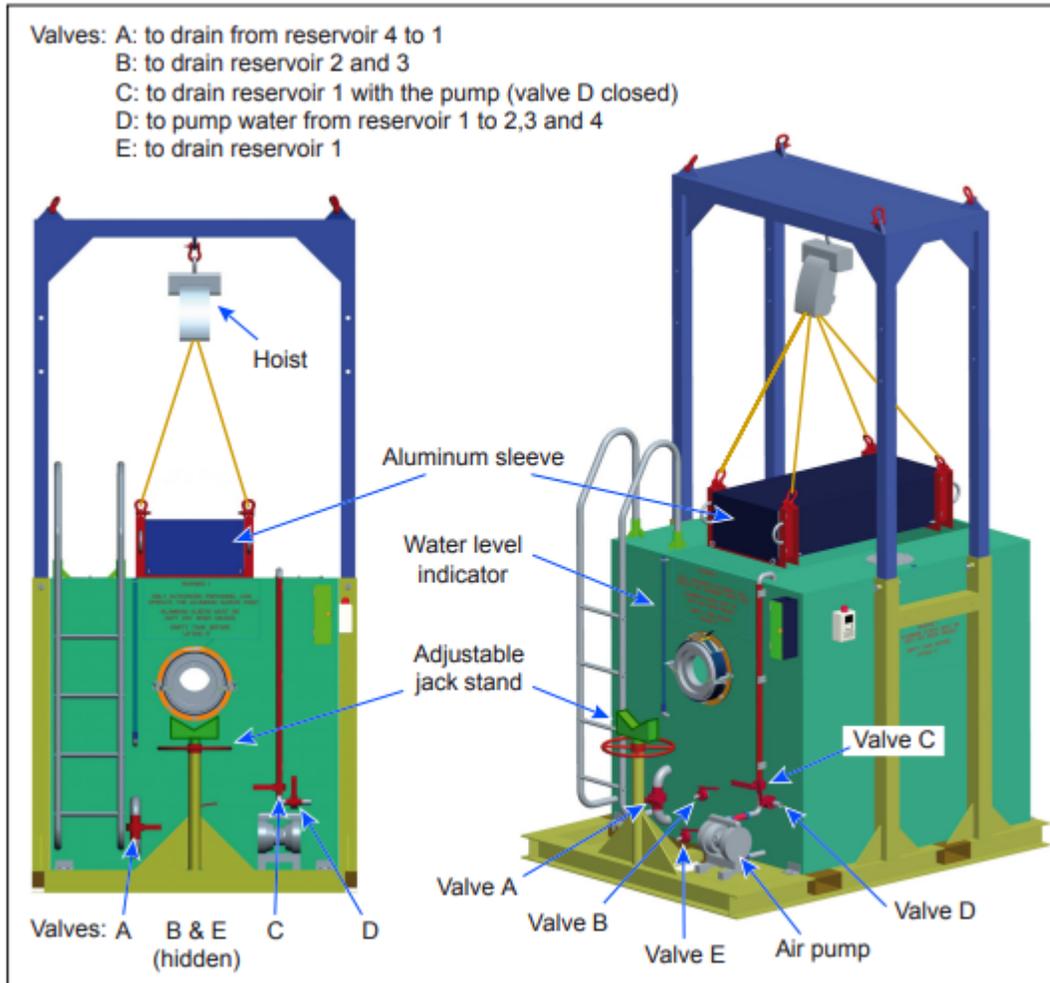


Figure 2.

6.0 Water Management Procedure in Calibration Tank

1. Install the NUCT-AA Tank for calibration. Figure 3



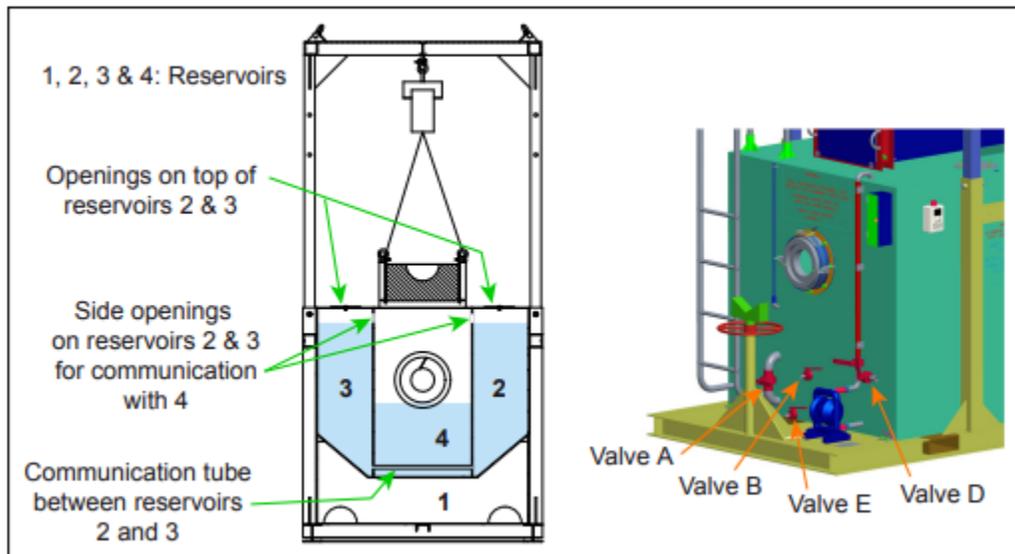
2. Inspect the future location of the tank:

- It must be installed in a "Controlled Radiation Area", with signs and physical barriers to prevent access.
- It must be easy to drain in case of water leak and without any water-sensitive item on the floor.
- It must be under an overhead crane and in line with crane moving direction.
- There must be a free distance of 14 meters [46 feet] minimum in the motion direction.
- There must be room enough around the set up to move freely and to place safety barriers and chains during the test.

3. Fill water reservoir. Figure 4:

- Use fresh water only, as filtered sea water, anti-freeze or other additives can affect the calibration accuracy
- Fill the tank with fresh water: a. Close the communication valve A (between reservoirs 1 and 4).
- Make sure that Valves A, B, D & E are closed.

- Fill reservoir 2 and 3 separately through their top opening until the water flows into reservoir 4 through the communication openings.
- Fill reservoir 4 until the water reaches the tool holes.
- Open Valve A and let water flow into the reservoir 1.
- Close Valve A when reservoir 4 is empty.
- Reservoirs 2 and 3 are linked by a thin communication tube. Anyway, it is faster to fill them separately.
- Fine level adjustment of water level will be done at first next calibration.
- As water is moved between tanks 1 and 4 during calibration, only minimum addition will be necessary to compensate for water losses.
- The water can be replaced once a year only
- Make sure that the water level alarm is installed in tank 4. The water level alarm detects a decrease of around 10 cm [4 in] under the nominal level. If lower than this, the detector count rate will be affected, and calibration will be wrong





7. Water Recycling System

There will be one water connection in the calibration room in which there is a 300mm wide trench forming the shape of a 6.3m x 2.5m rectangle. This trench is used as a secondary containment to block any water released. This trench would be cleaned by transferring directly from the trench to a 350-gallon tote with a diaphragm pump and hose and it would be sent to the recycling system that is full equipped with proper filters allowing water being reused anytime.

8. Reference

- Radiation B.O.O.K
- SWI. Install NUCT-AA Tank. Document content 7558588
- Neutron 4-Points Calibration Maintenance SWI
- Minitron Conditioning Procedure
- Density Gamma Ray Calibration Maintenance SWI

Controlled Document:

WORK INSTRUCTIONS

DATE	Document History.	Created by:	Location:
Jan 2023	First Version	Maximiliano Zurita Ciro Ramirez	Guyana

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**APPENDIX 5. MP35N: A SUPERALLOY FOR CRITICAL OIL AND GAS
APPLICATIONS.**

MP35N: A Superalloy for Critical Oil and Gas Applications

AUTHOR: THOMAS C. WILLIAMS, P.E. APPLICATIONS DEVELOPMENT ENGINEER – ENERGY, CARPENTER TECHNOLOGY CORPORATION

INTRODUCTION

The attractive properties of MP35N® have led to its adoption into critical equipment in industries including aerospace, medicine, mining, offshore equipment, and oil and gas production. Typical applications include fasteners, springs, wire, cables, medical prostheses, pump shafts, valve stems, pressure housings, and cold-worked tubing. Even at yield strengths exceeding 200 ksi (1380 MPa), MP35N possesses excellent corrosion resistance in harsh oil and gas environments including seawater, chloride brines, sweet gas, and sour gas. It is the highest strength alloy approved in NACE MR0175 [1] for use in unrestricted sour service, offering an unmatched combination of strength and corrosion resistance. The unique capabilities of MP35N are derived from the alloy's chemistry, premium melting technology, cold-working, and heat treatment.

MP35N (UNS R30035) is a vacuum induction melted (VIM), vacuum arc re-melted (VAR) superalloy with cobalt, nickel, chromium, and molybdenum as its primary alloying elements. Its nominal chemical composition by weight is 35% cobalt, 35% nickel, 20% chromium, and 10% molybdenum. The VIM VAR melt practice provides superior cleanliness and reduces the presence of non-metallic inclusions and residual elements, like carbon, that have deleterious effects on mechanical properties and corrosion resistance. MP35N is unique in its ability to be simultaneously strong, tough, and ductile with superior corrosion resistance. It can be strengthened beyond the capabilities of stainless steels and nickel-based alloys like 718 with equal or better corrosion resistance in many environments.

The high strength of MP35N is created by a combination of work hardening and an age hardening heat treatment. Yield strength in the high-strength cold-worked-and-aged condition can exceed 260 ksi (1793 MPa) with ductility near 40% reduction of area. Much of the strengthening occurs during cold working, and the annealed properties are like many stainless steels. Typical properties in the annealed condition are 150 ksi ultimate tensile strength, 60 ksi yield strength, 68% elongation, and 75% reduction of area.

The vast array of MP35N applications has led to discrete processing routes, with clear distinctions between processes used for oil and gas and aerospace equipment. As with other alloys like nickel-based alloy 718, the tradeoff is between higher strength levels preferred for aerospace applications versus the resistance to stress corrosion cracking and hydrogen embrittlement required for oil and gas equipment. This paper seeks to inform the reader on the basic alloy systems that give MP35N its unique properties, the industry specifications created by the aerospace and oil and gas industries for MP35N, and the resultant properties.

MICROSTRUCTURE

MP35N has a face centered cubic (FCC) microstructure in the annealed condition. This is like other nickel and cobalt-based alloys. The primary strengthening mechanism is the partial transformation of the FCC structure to a hexagonal close-packed (HCP) structure. The HCP phase forms as thin platelets varying in thickness from 20 to 3,000 angstroms along planes of the FCC matrix. The spacing of the HCP platelets is directly related to strength – closer spacing results in higher strength. The platelets are difficult to detect metallographically, typically requiring transmission electron microscopy with magnification on the order of 20,000 times to visualize.

The FCC phase is stable above 1200°F, whereas the HCP structure is stable below 800°F. However, the transformation from FCC to HCP cannot occur by temperature alone and requires mechanical deformation. The extent of the transformation, and final strength level, depends on the amount of mechanical deformation imparted at temperatures below 800°F. The most common methods of introducing deformation are cold-working processes like drawing and forming.

After mechanically working the material, further strengthening up to an additional 40 ksi occurs via an age-hardening heat treatment. Peak strengthening occurs at ageing temperatures between 800°F and 1200°F due to precipitation of a cobalt-molybdenum phase. Age hardening without mechanically deforming the materials to form the HCP structure has little effect because the cobalt-molybdenum phase forms at the interfaces between HCP platelets and the FCC matrix. Yield strengths greater than 260 ksi (1793 MPa) are possible in the high-strength condition.

CORROSION RESISTANCE

MP35N uniquely combines the corrosion resistance of stainless steels and nickel-based alloys with the strength levels of high-strength steels. It is the highest strength alloy approved in NACE MR0175 for use in sour service. It has excellent seawater corrosion resistance at all strength levels, and is resistant to attack in most mineral acids and hydrogen sulfide. The high levels of chromium and molybdenum give MP35N pitting and crevice corrosion resistance in chloride environments that exceeds the performance of 316 stainless steel and is like that of nickel alloy 625. NACE MR0175 [1] permits the use of MP35N processed per the specification for any in-situ combination of temperature, H₂S partial pressure, chloride concentration, and pH occurring in downhole production environments.

The VIM VAR melt practice limits the presence of elements like carbon, manganese, silicon, and aluminum that can form intermetallic phases, like chromium carbides, at grain boundaries that locally reduce corrosion resistance. The precipitation of these unwanted phases depletes chromium from the surrounding matrix in a process known as sensitization. This problem is pronounced in alloys like 316 stainless steel, particularly if high-temperature processes like welding are used during fabrication. The chemical composition of MP35N, combined with premium melting, alleviates these concerns.

The alloy is considered virtually immune to general, crevice, and stress corrosion, regardless of strength level or processing condition [2]. The FCC crystal structure of the MP35N matrix gives it excellent resistance to hydrogen embrittlement due to tight atomic spacing. This is especially true when compared to high-strength alloy steels with body centered cubic microstructures (tempered martensite) and precipitation hardened nickel alloys like 718. MP35N is resistant to hydrogen embrittlement at high strength levels compared to these alloys, and is typically susceptible only in the presence of cathodic protection systems or galvanic coupling to more active materials like alloy steels [2].

MP35N's resistance to hydrogen embrittlement is influenced by the thermal treatment applied after cold work. Kane et al. [3] demonstrated that MP35N is resistant to hydrogen embrittlement in many combinations of cold-work and thermal treatments in sour environments. However, the authors also discovered that cold-worked MP35N aged at 1100°F, near the peak-aged condition, was susceptible to hydrogen embrittlement from galvanic coupling to alloy steel in solutions both with and without H₂S. This effect was only observed on samples stressed transverse to the direction of cold-working. Further work by Kane [4] and Kane and Berkowitz [5] showed that higher ageing temperatures dramatically increased resistance to hydrogen embrittlement. This work was foundational to the establishment of the heat treatment practices now approved in NACE MR0175 [1].

To summarize, ageing between 1000°F and 1200°F maximizes strength, but also increases susceptibility to hydrogen embrittlement in the transverse direction, particularly when yield strength exceeds 250 ksi. Conversely, ageing temperatures near 1400°F considerably reduces the risk of hydrogen embrittlement, but yield strength is typically below 200 ksi [2]. As with precipitation-hardening nickel alloys, hardness is a poor predictor of environmental cracking resistance, as microstructural properties are the primary performance driver. In a study by Kolts [6], samples with heavy cold reduction but no ageing were shown to fail in a hydrogen-charging environment, while samples with the same level of cold reduction aged at 1500°F did not. The hardness values for these two conditions were roughly identical but showed disparate performance.

Krishnan et al. [7] examined the effect of various corrosive media relevant to oil and gas subsurface safety valves on MP35N torsion springs cold-worked and aged at 1200°F for 4 hr to a hardness of 51.6 HRC per the limits in NACE MR0175 [1] for MP35N springs. The authors found that a simulated sour gas production environment had no effect on the springs. A simulated acid-flowback environment produced localized corrosion only detectable via scanning electron microscope in regions with relatively rough surface finish, and no crack propagation or secondary cracking was observed. These springs were then subjected to 200 loading cycles following exposure to the corrosive media and did not fail. Further testing with galvanic coupling of the MP35N springs to alloy steel in a sour environment also failed to produce any noticeable corrosion damage. Failure of these springs was only induced by intentional exposure to 38% hydrochloric acid at 180 F with a solution pH of 0.5. The authors concluded that MP35N is a suitable material for subsurface safety valves in sour and acidized production environment, but emphasized the importance of a smooth surface finish. Evidence of hydrogen embrittlement was only found after exposure to an extreme environment following galvanic coupling to steel, as was the case in previous work.

KEY INDUSTRY SPECIFICATIONS

There are several industry specifications that are leveraged to control MP35N manufacturing within the oil and gas and aerospace industries; these include AMS 5844 [8], AMS 5845 [9], AMS 5758 [10], NACE MR0175 [1], and API 20F [11]. The properties required for fitness for service in sour and hydrogen charging environments typical of oil and gas production are enumerated in NACE MR0175 and API 20F. There has been some confusion in the oil and gas industry because these specifications sometimes reference limits like alloy chemistry and solution heat treatments in the AMS documents. In some cases, like the use of MP35N for springs per NACE MR0175, the ageing heat treatments overlap with the AMS limits. The following sections highlight the requirements of each specification and the key differentiations. A synopsis is shown in Table 1:

Table 1: Major Aerospace and Oil and Gas Specifications for MP35N	
Specification	Description
SAE AMS 5844	Solution treated and cold worked bar up to 1.75" diameter
SAE AMS 5845	Solution treated, cold worked, and aged bar up to 1.75" diameter
SAE AMS 5758	Solution treated bar up to 1.75" diameter
NACE MR0175	Heat treatment and hardness limits for use in sour service
API 20F	Processing requirements for corrosion resistant alloys used for bolting

SAE AMS 5844 Rev. H

AMS 5844 covers MP35N round bar up to 1.75 inches in diameter supplied in the solution treated and work strengthened condition. Chemistry limits are established as shown in Table 2 and VIM VAR melting is required for cleanliness.

Table 2: Chemistry Limits for MP35N in AMS 5844					
Element	min	max	Element	min	max
CARBON	-	0.025	NICKEL	33	37
MANGANESE	-	0.15	MOLYBDENUM	9	10.5
SILICON	-	0.15	TITANIUM	-	1
PHOSPHORUS	-	0.015	IRON	-	1
SULFUR	-	0.01	COBALT	remainder	
CHROMIUM	19	21			

AMS 5844 requires that bars be solution heat treated by heating to a temperature within the range 1900 to 1925 °F (1038 to 1052 °C), holding at the selected temperature within ±25 °F (±14 °C) for 4 to 8 hours, and cooling in air to room temperature. The hardness of the solution treated and cold worked bar shall be 38 HRC or greater per ASTM E18 and the grain size per ASTM E112 shall be 4 or finer.

Mechanical property requirements for material following an age hardening heat treatment within the range 1000 to 1200 °F (538 to 649 °C), holding at the selected temperature within ±25 °F (±14 °C) for 4 to 4-1/2 hours, and cooling in air to room temperature are as follows in Table 3:

Table 3: Mechanical Properties after Ageing Required by AMS 5844	
Property	Value
Tensile Strength	260 ksi (1793 MPa)
Yield Strength at 0.2% Offset	230 ksi (1586 MPa)
Elongation in 4D	8%
Reduction of Area	35%

Mechanical property requirements for bars larger than 1.75 inch (44.4 mm) diameter shall be agreed upon between purchaser and producer. The mechanical properties after ageing are required as a capability demonstration, but the material is supplied in the solution treated and cold worked condition with the age hardening heat treatment at the supplier omitted.

SAE AMS 5845 Rev. J

SAE AMS 5845 covers MP35N round bar up to 1.75 inches in diameter in the solution heat treated, work strengthened, aged, and centerless ground condition. The VIM VAR melt practice and chemistry limits are identical to those in AMS 5844, shown in Table 2. The solution annealing and age hardening heat treatments are also identical to those in AMS 5844 and are summarized in Table 4:

Table 4: Summary of Heat Treatments for AMS 5844/5845	
Heat Treatment	Procedure
Solution Annealing	1900 to 1925 °F (1038 to 1052 °C), hold the selected temperature within ±25 °F (±14 °C) for 4 to 8 hours, and air cool to room temperature
Age Hardening	1000 to 1200 °F (538 to 649 °C), hold the selected temperature within ±25° F (±14 °C) for 4 to 4.5 hours, and air cool to room temperature

The required mechanical and microstructural properties after ageing are shown in Table 5:

Mechanical property requirements for bars larger than 1.75-inch (44.4 mm) diameter shall be agreed upon between purchaser and producer as in AMS 5844.

SAE AMS 5758 Rev. J

AMS 5758 covers MP35N in the solution treated condition. The chemical composition limits are identical to those in Table 2 for AMS 5844 and AMS 5845, and VIM VAR melting is required. The solution annealing heat treatment is identical to that listed in Table 4 for AMS 5844 and AMS 5845. AMS 5758 requires that mechanical properties in the solution treated condition be within the limits listed in Table 6.

The material shall achieve the mechanical properties shown in Table 3 and when cold worked on a straight draw bench to 53% ± 1% cold reduction based on cross-sectional area and age hardened between 1000 to 1200°F per the heat treatment listed in Table 4. Like AMS 5844, the testing in the cold worked and aged condition is for capability testing only, and the material is supplied to the customer in the solution treated condition absent of cold work or ageing treatment.

Table 5: MP35N Property Requirements in AMS 5845	
Property	Value
Tensile Strength	260 ksi (1793 MPa)
Yield Strength at 0.2% Offset	230 ksi (1586 MPa)
Elongation in 4D	8%
Reduction of Area	35%
Hardness per ASTM E18	44 HRC min
Grain Size per ASTM E112	4 or finer

Table 6: MP35N Property Requirements in the Solution Treated Condition per AMS AMS 5758	
Property	Value
Tensile Strength	115 to 145 ksi (793 to 1000 MPa)
Yield Strength at 0.2% Offset	35.0 to 65 ksi (241 to 448 MPa)
Elongation in 4D, min	50%
Reduction of Area, min	65%
Hardness per ASTM E10	241 HB max
Grain Size per ASTM E112	4 or finer

NACE MR0175/ISO 15156 Third Edition, 2015

NACE MR0175 controls the ageing treatment of MP35N to limit its susceptibility to environmental cracking in the presence of hydrogen sulfide. There are two sets of approved processing and property limits for MP35N: one governs its use for any equipment or component, the other for use as springs. The chemistry limits listed in MR0175 are identical to those listed in AMS specifications 5844, 5845, and 5758, and shown in Table 2. The AMS specifications will sometimes be listed to control melt practice, chemistry, and solution annealing on orders for material complying to the ageing and hardness limits in NACE MR0175.

MP35N shall have a maximum hardness of 51 HRC in the solution-treated, cold-worked, and aged condition when used for any equipment or component. The required ageing treatments for MR0175 are listed in Table 7. MP35N has a hardness limit of 35 HRC if it is not aged per Table 7. It is worth noting that the maximum allowable hardness for cold worked material in NACE MR0175 is less than the minimum of 38 HRC allowed for the same condition in AMS 5844.

NACE MR0175 permits a higher hardness limit of 55 HRC when MP35N is used for springs in the cold-worked-and-aged condition. The permissible age hardening treatment is also different, as shown in Table 8. The ageing treatment for springs can create some confusion with the AMS specifications, as the temperature and time limits fall within the range listed in AMS 5844, 5845 and 5758.

API 20F Second Edition, 2018

The second edition of API specification 20F became effective in November 2018 and covers bolting manufactured from corrosion resistant alloys. The scope of the document includes the precipitation hardened nickel alloys covered in API 6ACRA, alloy A286 (ASTM A453 grade 660), and MP35N. This specification draws on processing and property requirements from AMS 5844 and NACE MR0175. API 20F increases the rigor of quality and process controls applied to critical bolting for the oil and gas industry.

For MP35N, the bolting manufacturer is required to have a written specification that complies with the SAE AMS 5844 chemistry, melting practice, solution annealing, furnace tolerances, and average grain size. The ageing procedures and hardness limitations are dictated by those in NACE MR0175. Solution-treated-and-cold-worked material is limited to a maximum hardness of 35 HRC as in MR0175. Material supplied in the solution treated, cold worked, and aged condition must be aged per one of the conditions listed in NACE MR0175 (see Table 7) with a maximum allowable hardness of 51 HRC. Furthermore, heat treatment of MP35N is only to be performed by the raw material supplier/mill. A summary of the MP35N hardness limits in API 20F and NACE MR0175 is provided in Table 9.

Table 7: MP35N Age Hardening Times and Temperatures per NACE MR0175

Minimum Time (hrs)	Temperature °C (°F)
4	704 (1,300)
4	732 (1,350)
6	774 (1,425)
4	788 (1,450)
2	802 (1,475)
1	816 (1,500)

Table 8: MP35N Age Hardening Treatment for Springs per NACE MR0175

Time	Temperature
4 hrs minimum	649 °C (1,200 °F) minimum

Table 9: Summary of MP35N Hardness Limits in API 20F and NACE MR0175

Condition	Hardness Limit		
	API 20F	NACE MR0175 Any Equipment	NACE MR0175 Springs
Solution treated and cold worked	35 HRC max	35 HRC max	-
Solution treated, cold worked, and aged	51 HRC max	51 HRC max	55 HRC max

Bolting manufacturers are responsible for qualifying raw material suppliers, defined as a melting mill in API 20F, for each grade and heat treatment condition, based on quality assurance and technical practices. They must also ensure that raw material suppliers have appropriate controls over critical processes and must ensure on-site technical and quality audits are performed at least every three years. On-site audits of raw material suppliers are optional for bolting specification level (BSL) two, and mandatory for BSL three. Raw material suppliers are responsible for maintaining quality management systems and process controls with documented procedures. Bolting manufacturers are also responsible for developing material specifications to document raw material requirements. Specification of the chemistry limits, melt practice, ladle refinement, heat treatment, mechanical properties, and inspection criteria are required for MP35N. Specification of the cold work practice for MP35N is not required.

Bolting manufacturers are also responsible for qualifying bolting for service at BSLs two and three. Changes to manufacturing processes, including those at the raw material supplier related to equipment and processing, require requalification via a qualified laboratory. Changes to MP35N total cold reduction also triggers requalification. The practices have been implemented to place quality and process controls around the most critical fasteners for the oil and gas industry.

PROCESSING MP35N FOR OIL AND GAS APPLICATIONS

Solution Annealing

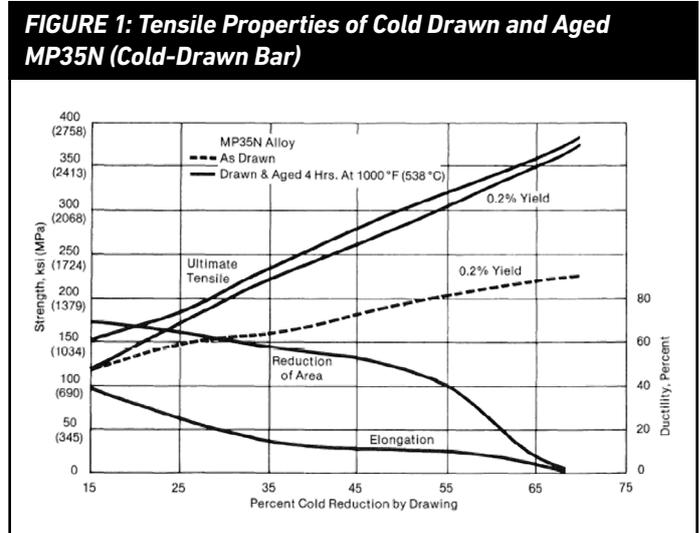
The chemistry and solution annealing treatments used for oil and gas applications are identical to the limits in AMS 5758, 5844, and 5845. However, the subsequent cold work and ageing steps must be modified to meet the limits of NACE MR0175 and API 20F. Furthermore, the AMS specifications only govern bar up to 1.75 inches in diameter and raw material for many oil and gas applications exceeds this limit.

Cold Working

The cold working of MP35N is the most critical step in the manufacturing process. The precipitation of nano-scale HCP platelets in the FCC microstructure is the primary strengthening mechanism, and this cannot occur without cold working the material. The degree of transformation, and the amount of strengthening, is directly proportional to the amount of cold work. This effect is illustrated in Figure 1.

The HCP platelets can be formed by working the material at temperatures as high as 800°F. The HCP platelets are thermodynamically stable up to about 1200°F, at which point they begin to dissolve, and the material loses strength. This causes the lower strength levels in material conforming to NACE MR0175 compared to aerospace product per AMS 5844/5845/5758. The one exception to this case is material used to make mechanical springs, which can be aged at 1200°F per NACE MR0175.

There are several methods available for cold working MP35N including drawing, cold forging, cold rolling, metal spinning, pilgering, and flow forming. Drawing is the most common method used for MP35N production in the bar form. However, limitations on tooling and safety concerns limit the maximum practical finished bar diameter to around three inches. Cold forging operations, particularly rotary



forging, can also be utilized for larger bar sizes, but this entails considerable challenges with tooling and machine wear. Cold rolling of MP35N sheet is common and enables fabrication of MP35N components of considerable size, but with sheet metal wall thickness. Cold-rolled plates of smaller planform area are also possible up to thicknesses of approximately 2.5 inches. Flow forming is a similar process that begins with a thicker annealed sheet and cold works it into axisymmetric thin-walled products like nose cones for missiles. Flow forming and pilgering enable manufacturing of cold-worked, seamless tubulars of much larger diameter than possible with bored bar, but these processes are typically limited to cold-worked wall thicknesses of one inch or less.

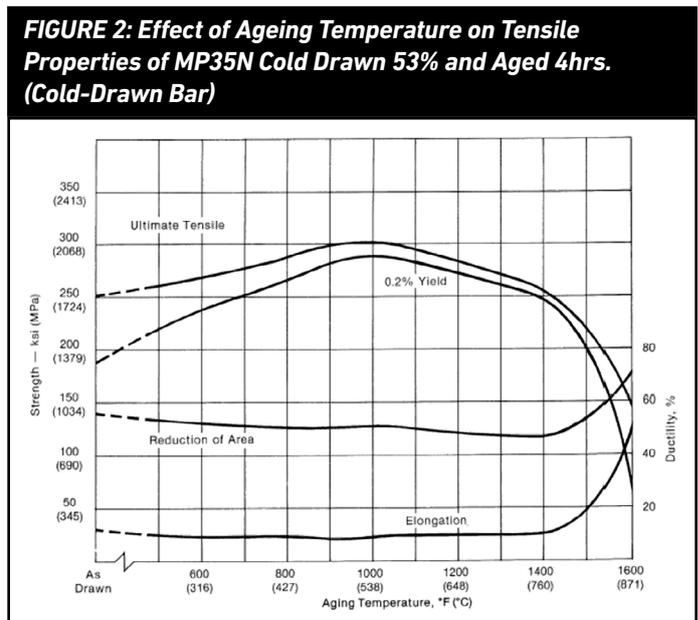
Age Hardening

Further strengthening can be achieved by ageing MP35N following cold work. This effect is illustrated by the yield strength curves in Figure 2, where further strengthening beyond cold work is achieved. This effect is amplified as the amount of cold work increases.

Increased strength in the aged condition is achieved by the precipitation of Co_3Mo particles that interact with the FCC matrix. These precipitates nucleate due to segregation of molybdenum atoms at temperatures above 800°F at the interface between the FCC matrix and the HCP platelets formed by cold work. The Co_3Mo phase inhibits the interaction of dislocation sources, improving the strength of the alloy.

Peak ageing occurs at approximately 1000°F, and breakdown of the HCP platelets begins above 1200°F. The heat treatments included in NACE MR0175 for equipment other than springs put the material in an over-aged condition.

It is critical to note that the formation of the Co_3Mo precipitates can only occur when the HCP phase is present. Thus, ageing the alloy without cold work will not strengthen the material. It is impossible to recover strength in an MP35N part in its finished form if it is solution annealed following cold work. For this reason, bolting manufacturers conforming to API 20F are only allowed to machine fasteners from material delivered by the raw material supplier in the cold-worked-and-aged condition.



CARPENTER TECHNOLOGY'S MILL-MINIMUM PROPERTIES

The following minimum properties apply to MP35N supplied as bar product. It is also possible to convert MP35N into additional forms like plate, strip, sheet, wire, plate, and tubular products through other conversion processes. Carpenter Technology Corporation's standard product forms for MP35N are annealed billet and cold-worked and aged bar, wire, and strip.

AMS 5844

Carpenter Technology performs capability testing on MP35N bar ordered per AMS 5844 in the solution treated and work-strengthened condition and has established the minimum properties shown in Table 10 following age hardening per AMS 5844. The as-shipped hardness is based on properties following solution annealing and cold work, prior to age hardening.

Table 10: Carpenter Technology's Minimum Properties for MP35N per AMS 5844

Age Temperature	Bar Diameter	YS (ksi)	UTS (ksi)	% EL	% RA	HRC (as shipped)
1000°F to 1200°F	< 1.75 in	230	260	8	35	38 minimum
1000°F to 1200°F	> 1.75" to 2.00 in	225	235	8	35	38 minimum
1000°F to 1200°F	> 2.00" to 3.25 in	185	195	10	40	Information Only

AMS 5845

The properties listed in Table 11 are minimums for MP35N bar ordered per AMS 5845. As-shipped hardness is guaranteed only up to 1.75 inches, which is the upper size limit of the AMS 5845 specification.

Table 11: Carpenter Technology's Minimum Properties for MP35N per AMS 5845

Age Temperature	Bar Diameter	YS (ksi)	UTS (ksi)	% EL	% RA	HRC (as shipped)
1000°F to 1200°F	< 1.75 in	230	260	8	35	44 minimum
1000°F to 1200°F	> 1.75" to 2.00 in	225	235	8	35	Information Only
1000°F to 1200°F	> 2.00" to 3.25 in	185	195	10	40	Information Only

NACE MR0175

Carpenter Technology's minimum properties for material in the cold-worked-and-aged condition per NACE MR0175 are shown in Table 12. The 1425°F/6hr age condition is popular for subsea bolting, particularly for bar sizes 2 inches and below. Most NACE-compliant cold-worked-and-aged material above 2 inches diameter is supplied in the 1300°F/4hr aged condition, which achieves the highest strength in this size range. Cherry-picking distributors' inventory is done to supply material with higher strength levels than the guarantees below for specific applications. As expected, the minimum yield strength increases as ageing temperature decreases.

Table 12: Carpenter Technology's Minimum Properties for MP35N per NACE MR0175

Age Temperature	Time	Diameter (in)	YS (ksi)	UTS (ksi)	% EL	% RA	HRC
1425°F	6 hrs	≤ 2.00	180	190	10	40	51 max
1425°F	6 hrs	> 2.00 to 3.25	160	170	12	40	51 max
1350°F	4 hrs	≤ 2.00	200	210	10	40	51 max
1350°F	4 hrs	> 2.00 to 3.25	165	175	12	40	51 max
1300°F	4 hrs	≤ 1.50	210	220	10	40	51 max
1300°F	4 hrs	> 2.00 to 3.25	175	185	12	40	51 max

MACHINING

The machinability of MP35N varies depending on the condition of the material and is like that of the nickel-cobalt-chromium alloy Waspaloy®. MP35N can be machined in the cold-worked-and-aged condition. The following speeds and feed rates are recommended for drilling [2]: 7.6 m/min (25 sfm) and 0.10 mm/rev (0.005 in./rev) feed. The following are recommended for turning: 9.1 m/min (30 sfm) and 0.254 mm/rev (0.010 in./rev) feed. High-speed steels and carbide tools can be used. Recommended cutting fluids include soluble oil, sulfurized oil, or chlorinated oil.

WELDING

The welding of MP35N is like that of 304 stainless steel and the same preparations and precautions may be used [2]. The following parameters have been recommended for gas tungsten arc welding (GTAW) based on work with 1.5 mm (0.060 in.) thick sheet and 6.4 mm (1.250 in.) thick plate:

- Argon gas flow rate: 9.4 to 11.8 L/min (20–25 ft³/h)
- Weld speed: 140 mm/min (5.5 in./min)
- Voltage: 10 V
- MP35N filler wire feed: 355 to 560 mm/min (14–22 in./min)

It is important to keep the heat input per pass low: approximately 50% to 65% of that used for type 304 stainless steel. The following parameters were used for the GTAW trials: currents of 50 to 60 A were used for the sheet. Total heat input was 2165 to 3740 J/cm (5500–9500 J/in). For plate, the current ranged from 100 to 160 A and heat inputs were 4330 to 7480 J/cm (11,000–19,000 J/in).

The weld's heat affected zone (HAZ) will have been weakened by the elevated temperatures in the near-weld region. Unfortunately, it is not possible to recover strength in the HAZ simply by using a post-weld heat treatment. The weld can be solution treated to relieve residual stresses from welding but strengthening is only possible through a subsequent cold work process.

CONCLUSIONS

MP35N possesses excellent corrosion resistance in harsh environments including seawater, chloride brines, sweet gas, and sour gas. MP35N is the highest strength alloy approved in NACE MR0175 for use in sour service. MP35N derives its strength from a combined cold-work and heat treatment process.

- MP35N cannot be strengthened by heat treatment alone
- The heat treatment of MP35N for oil and gas applications typically complies with the procedure in NACE MR0175
- Oil and gas applications typically use the chemistry and solution annealing limits in AMS 5844. Material is sometimes ordered to AMS 5844, then aged to comply with NACE MR0175. However, this is not a recommended practice as the cold work processes used in the mill for AMS and NACE MR0175-compliant material may be different and hardness after ageing cannot be guaranteed to fall within NACE MR0175 limits.
- The second edition of API 20F was released in 2018 and governs bolting made from MP35N. Bolting manufacturers are required to purchase MP35N in the mill-heat-treated condition and no additional forging is allowed.
- Machining MP35N in the cold-worked-and-aged condition can be difficult but is readily done with the proper combination of feeds, speeds, cutting tools, and cutting fluids.
- MP35N can be welded easily, but the strength of the heat affected zone must be considered.

REFERENCES

- [1] ANSI/NACE MR0175/ISO 15156-3:2015 Third Edition, "Petroleum, petrochemical, and natural gas industries - Materials for use in H₂S-containing environments in oil and gas production," NACE, Houston, 2015.
- [2] ASM International, Nickel, Cobalt, and Their Alloys, J. Davis and D. a. Associates, Eds., Materials Park, OH: ASM International, 2000.
- [3] R. Kane, M. "Watkins, D. Jacobs and G. Hancock, "Factors Influencing the Embrittlement of Cold Worked High Alloy Materials in H₂S Environments," Corrosion, vol. 33, no. 9, pp. 309-320, 1977.
- [4] R. D. Kane, "Accelerated Hydrogen Charging of Nickel and Cobalt Base Alloys," Corrosion, vol. 34, no. 12, pp. 442-445, 1978.
- [5] R. Kane and B. Berkowitz, "Effect of Heat Treatment and Impurities on the Hydrogen Embrittlement of a Nickel Cobalt Base Alloy," Corrosion, vol. 36, no. 1, pp. 29-36, 1980.
- [6] J. Kolts, "Laboratory Evaluation of Corrosion Resistant Alloys for the Oil and Gas Industry," in NACE Corrosion, Houston, 1986.
- [7] K. Krishnan and S. Meney, "Embrittlement of MP35N (UNS R30035) Springs in Simulated Downhole Production and Acid Stimulation Environments," in NACE Corrosion, Houston, 2012.
- [8] AMS 5844 - Aerospace Material Specification, "Alloy, Corrosion-Resistant, Round Bars 20Cr - 35Ni - 35Co - 10Mo Vacuum Induction Plus Consumable Electrode Vacuum Remelted Solution Heat Treated and Work Strengthened," SAE International, Warrendale, PA, 2014.
- [9] AMS 5845 - Aerospace Material Specification, "Alloy, Corrosion-Resistant, Round Bars 20Cr - 35Ni - 35Co - 10Mo Vacuum Induction Plus Consumable Electrode Vacuum Remelted Solution Heat Treated, Work Strengthened, and Aged," SAE International, Warrendale, PA, 2014.
- [10] AMS 5758 - Aerospace Material Specification, "Alloy, Corrosion-Resistant, Bars 20Cr - 35Ni - 35Co - 10Mo Vacuum Induction Plus Consumable Electrode Vacuum Remelted Solution Heat Treated for Work Strengthening," SAE International, Warrendale, PA, 2014.
- [11] API Specification 20F, "Corrosion-resistant Bolting for Use in Petroleum and Natural Gas Industries," American Petroleum Institute, Washington, D.C., 2018.

The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes. There is no representation that the recipient of this literature will receive updated editions as they become available. Trademarks are registered trademarks of CRS Holdings, Inc., a subsidiary of Carpenter Technology Corporation. Copyright 2019 CRS Holdings, Inc. All rights reserved.

Source Storage and Calibration Building
Schlumberger Guyana Inc.

APPENDIX 6. GENERATOR. MANUFACTURER'S SPECIFICATION SHEET.



Central States Diesel Generators

Cummins - DFEK 500kW Generator

1. Bill of Material
2. Generator Set Information
3. Generator Warranty
4. Generator Outline & Foundation Drawings

BILL OF MATERIALS

Project Name: Central States Diesel Generators

Item	Description	Qty
	Diesel Genset: 60Hz-500/455kW	
Install-US-Stat	U.S. EPA, Stationary Emergency Application	1
500DFEK	Genset-Diesel,60Hz,500kW-Standby Rating	1
A331-2	Duty Rating-Standby Power	1
L090-2	Listing-UL 2200	1
L170-2	Emissions Certification, EPA, Tier 2, NSPS CI Stationary Emergency	1
F200-2	Enclosure-Steel,Weather Prot,Base Mtd,w/ExhSys	1
C207-2	Fuel Tank-Subbase,850 Gallon,UL142 Compliant	1
R002-2	Voltage-277/480,3 Phase,Wye,4 Wire	1
B246-2	Alternator-60 Hz, 12 Lead, Limited Range, 125/105C	1
H703-2	Generator Set Control-PowerCommand 2.3	1
H536-2	Display Language-English	1
H678-2	Display-Control, LCD	1
H609-2	Control Mounting-Left Facing	1
KU94-2	CB or EB or TB-Right Only	1
KC62-2	Circuit Breaker-800A,Right CB on Right side,3-Pole,UL 600,IEC 690 100%	1
KB72-2	CB or EB or TB-Bottom Entry, Right	1
P175-2	Enclosure Color-Green,Steel Enclosure	1
L163-2	Listing, ULC-S601-07	1
C127-2	Separator-Fuel/Water	1
E074-2	Engine Cooling-Radiator, 50C Ambient	1
H389-2	Shutdown-Low Coolant Level	1
H556-2	Coolant Heater-208/240/480V, 40F Minimum Ambient Temp	1
D041-2	Engine Air Cleaner-Normal Duty	1
L028-2	Genset Warranty- Base 2 Years or 1000 Hours	1
A048G602	Battery Charger-10Amp,120/208/240VAC,12/24V,50/60Hz	1



Diesel generator set QSX15 series engine

450 kW – 500 kW Standby



Description

Cummins® commercial generator sets are fully integrated power generation systems providing optimum performance, reliability and versatility for stationary standby and prime power applications.

Features

Cummins heavy-duty engine - Rugged 4-cycle, industrial diesel delivers reliable power, low emissions and fast response to load changes.

Alternator - Several alternator sizes offer selectable motor starting capability with low reactance 2/3 pitch windings, low waveform distortion with non-linear loads and fault clearing short-circuit capability.

Permanent Magnet Generator (PMG) - Offers enhanced motor starting and fault clearing short-circuit capability.

Control system - The PowerCommand® electronic control is standard equipment and provides total genset system integration including automatic remote starting/stopping, precise frequency and voltage regulation, alarm and status message display, AmpSentry™ protection, output metering, auto-shutdown at fault detection and NFPA 110 Level 1 compliance.

Cooling system - Standard integral set-mounted radiator system, designed and tested for rated ambient temperatures, simplifies facility design requirements for rejected heat.

Enclosures - Optional weather protective and sound attenuated enclosures are available.

Fuel tanks - Dual wall sub-base fuel tanks are also available.

NFPA - The genset accepts full rated load in a single step in accordance with NFPA 110 for Level 1 systems.

Warranty and service - Backed by a comprehensive warranty and worldwide distributor network.

	Standby rating	Prime rating	Continuous rating	Data sheets
Model	60 Hz kW (kVA)	60 Hz kW (kVA)	60 Hz kW (kVA)	60 Hz
DFEJ	450 (563)	410 (513)		D-3400
DFEK	500 (625)	455 (569)		D-3401

Generator set specifications

Governor regulation class	ISO 8528 part 1 Class G3
Voltage regulation, no load to full load	± 0.5%
Random voltage variation	± 0.5%
Frequency regulation	Isochronous
Random frequency variation	± 0.25%
EMS compatibility	IEC 61000-4-2: Level 4 Electrostatic discharge IEC 61000-4-3: Level 3 Radiated susceptibility

Engine specifications

Design	Turbocharged with air-to-air charge air-cooling
Bore	136.9 mm (5.39 in.)
Stroke	168.9 mm (6.65 in.)
Displacement	14.9 L (912.0 in ³)
Cylinder block	Cast iron with replaceable wet liners, in-line 6 cylinder
Battery capacity	1400 Amps minimum at ambient temperature 0 °C (32 °F)
Battery charging alternator	35 Amps
Starting voltage	24 volt, negative ground
Fuel system	Full authority electronic (FAE) Cummins HPI-TP
Fuel filter	
Air cleaner type	
Lube oil filter type(s)	Single spin-on combination full flow and bypass filters
Standard cooling system	40 °C (104 °F) ambient radiator

Alternator specifications

Design	Brushless, 4 pole, drip-proof revolving field
Stator	2/3 pitch
Rotor	Single bearing, flexible discs
Insulation system	Class H
Standard temperature rise	125 °C standby at 40 °C ambient
Exciter type	PMG (Permanent Magnet Generator)
Phase rotation	A (U), B (V), C (W)
Alternator cooling	Direct drive centrifugal blower fan
AC waveform total harmonic distortion (THDV)	< 5% no load to full linear load, < 3% for any single harmonic
Telephone influence factor (TIF)	< 50% per NEMA MG1-22.43
Telephone harmonic factor (THF)	< 3%

Available voltages

60 Hz Line – Neutral/Line - Line

• 110/190	• 110/220	• 115/200	• 115/230
• 120/208	• 127/220	• 139/240	• 220/380
• 230/400	• 240/416	• 255/440	• 277/480
• 347/600			

Note: Consult factory for other voltages.

Generator set options

Engine

- 208/240/480 V thermostatically controlled coolant heater for ambient above 4.5 °C (40°F)
- 208/240/480 V thermostatically controlled coolant heater for ambient below 4.5 °C (40°F)
- 120 V 300 W lube oil heater
- Heavy duty air cleaner with safety element

Alternator

- 80 °C rise
- 105 °C rise
- 150 °C rise
- 120/240 V 200 W anti-condensation heater

Exhaust system

- Critical grade exhaust silencer
- Exhaust packages
- Industrial grade exhaust silencer
- Residential grade exhaust silencer

Fuel system

- 1022 L (270 gal) sub-base tank
- 1136 L (300 gal) sub-base tank
- 1514 L (400 gal) sub-base tank
- 1893 L (500 gal) sub-base tank
- 2271 L (600 gal) sub-base tank
- 2498 L (660 gal) sub-base tank
- 3218 L (850 gal) sub-base tank
- 6435 L (1700 gal) sub-base tank
- 9558 L (2525 gal) sub-base tank

Cooling system

- High ambient 50 °C radiator

Control panel

- PC 3.3
- PC 3.3 with MLD
- 120/240 V 100 W control anti-condensation heater
- Ground fault indication
- Remote fault signal package
- Run relay package

Generator set

- AC entrance box
- Battery
- Battery charger
- Export box packaging
- UL 2200 Listed
- Main line circuit breaker
- Paralleling accessories
- Remote annunciator panel
- Spring isolators
- Enclosure: aluminium, steel, weather protective or sound attenuated
- 2 year standby power warranty
- 2 year prime power warranty
- 5 year basic power warranty
- 10 year major components warranty

*Note: Some options may not be available on all models - consult factory for availability.

Control system 2.3

The PowerCommand 2.3 control system - An integrated generator set control system providing voltage regulation, engine protection, generator protection, operator interface and isochronous governing (optional).

Control - Provides battery monitoring and testing features and smart-starting control system.

InPower™ - PC-based service tool available for detailed diagnostics.

PCCNet RS485 - Network interface (standard) to devices such as remote annunciator for NFPA 110 applications.

Control boards - Potted for environmental protection.

Ambient operation - Suitable for operation in ambient temperatures from -40 °C to +70 °C and altitudes to 13,000 feet (5000 meters). Prototype tested - UL, CSA and CE compliant.

AC protection

- AmpSentry protective relay
- Over current warning and shutdown
- Over and under voltage shutdown
- Over and under frequency shutdown
- Over excitation (loss of sensing) fault
- Field overload
- Overload warning
- Reverse kW shutdown
- Reverse Var shutdown
- Short circuit protection

Engine protection

- Overspeed shutdown
- Low oil pressure warning and shutdown
- High coolant temperature warning and shutdown
- Low coolant level warning or shutdown
- Low coolant temperature warning

- High, low and weak battery voltage warning
- Fail to start (overcrank) shutdown
- Fail to crank shutdown
- Redundant start disconnect
- Cranking lockout
- Sensor failure indication
- Low fuel level warning or shutdown
- Fuel-in-rupture-basin warning or shutdown

Operator/display panel

- Manual off switch
- 128 x 128 Alpha-numeric display with push button access for viewing engine and alternator data and providing setup, controls and adjustments (English or international symbols)
- LED lamps indicating genset running, not in auto, common warning, common shutdown, manual run mode and remote start
- Suitable for operation in ambient temperatures from -20 °C to +70 °C

Alternator data

- Line-to-Neutral AC volts
- Line-to-Line AC volts
- 3-phase AC current
- Frequency
- kVA, kW, power factor

Engine data

- DC voltage
- Lube oil pressure
- Coolant temperature

Control functions

- Time delay start and cool down
- Glow plug control (some models)
- Cycle cranking
- PCCNet interface
- (4) Configurable inputs
- (4) Configurable outputs
- Remote emergency stop
- Battle short mode
- Load shed
- Real time clock with exerciser
- Derate

Digital governing (optional)

- Integrated digital electronic isochronous governor
- Temperature dynamic governing

Digital voltage regulation

- Integrated digital electronic voltage regulator
- 3-phase Line-to-Line sensing
- Configurable torque matching
- Fault current regulation under single or three phase fault conditions

Other data

- Genset model data
- Start attempts, starts, running hours
- Fault history
- RS485 Modbus® interface
- Data logging and fault simulation (requires InPower service tool)
- Total kilowatt hours
- Load profile

Options

- Auxiliary output relays (2)
- 120/240 V, 100 W anti-condensation heater
- Remote annunciator with (3) configurable inputs and (4) configurable outputs
- PMG alternator excitation
- PowerCommand for Windows® remote monitoring software (direct connect)
- AC output analogue meters
- PowerCommand 2.3 and 3.3 control with AmpSentry protection

For further detail on PC 2.3 see document S-1569.

For further detail on PC 3.3 see document S-1570.

Emergency Standby Power (ESP):

Applicable for supplying power to varying electrical load for the duration of power interruption of a reliable utility source. Emergency Standby Power (ESP) is in accordance with ISO 8528. Fuel Stop power in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.

Limited-Time running Power (LTP):

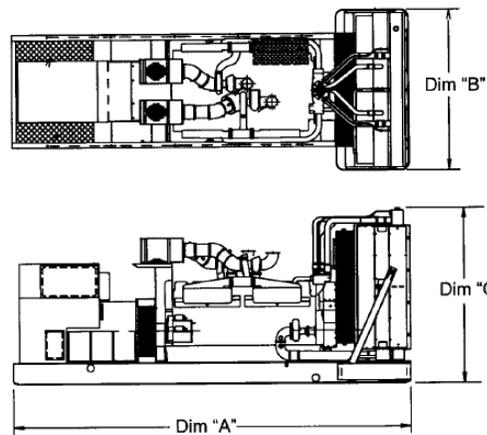
Applicable for supplying power to a constant electrical load for limited hours. Limited Time Running Power (LTP) is in accordance with ISO 8528.

Prime Power (PRP):

Applicable for supplying power to varying electrical load for unlimited hours. Prime Power (PRP) is in accordance with ISO 8528. Ten percent overload capability is available in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.

Base Load (Continuous) Power (COP):

Applicable for supplying power continuously to a constant electrical load for unlimited hours. Continuous Power (COP) in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.



This outline drawing is for reference only. See respective model data sheet for specific model outline drawing number.

Do not use for installation design

Model	Dim 'A' mm (in.)	Dim 'B' mm (in.)	Dim 'C' mm (in.)	Set weight dry* kg (lbs)	Set weight wet* kg (lbs)
DFEJ	3864 (152.1)	1524 (60.0)	1812 (71.3)	4098 (9035)	4234 (9335)
DFEK	3864 (152.1)	1524 (60.0)	1812 (71.3)	4325 (9535)	4461 (9835)

*Weights represent a set with standard features. See outline drawings for weights of other configurations.

Codes and standards

Codes or standards compliance may not be available with all model configurations – consult factory for availability.

	<p>This generator set is designed in facilities certified to ISO 9001 and manufactured in facilities certified to ISO 9001 or ISO 9002.</p>		<p>The generator set is available listed to UL 2200, Stationary Engine Generator Assemblies for all 60 Hz low voltage models. The PowerCommand control is Listed to UL 508 - Category NITW7 for U.S. and Canadian usage. Circuit breaker assemblies are UL 489 Listed for 100% continuous operation and also UL 869A Listed Service Equipment.</p>
	<p>The Prototype Test Support (PTS) program verifies the performance integrity of the generator set design. Cummins products bearing the PTS symbol meet the prototype test requirements of NFPA 110 for Level 1 systems.</p>	<p>U.S EPA</p>	<p>Engine certified to Stationary Emergency U.S. EPA New Source Performance Standards, 40 CFR 60 subpart IIII Tier 2 exhaust emission levels. U.S. applications must be applied per this EPA regulation.</p>
	<p>All low voltage models are CSA certified to product class 4215-01.</p>	<p>International Building Code</p>	<p>The generator set package is available certified for seismic application in accordance with the following International Building Code: IBC2000, IBC2003, IBC2006, IBC2009 and IBC2012.</p>

Warning: Back feed to a utility system can cause electrocution and/or property damage. Do not connect to any building's electrical system except through an approved device or after building main switch is open.

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Generator set data sheet



Model: DFEK
Frequency: 60 Hz
Fuel type: Diesel
kW rating: 500 Standby
 455 Prime
Emissions level: EPA NSPS Stationary Emergency Tier 2

Exhaust emission data sheet:	EDS-173
Exhaust emission compliance sheet:	EPA-1005
Sound performance data sheet:	MSP-177
Cooling performance data sheet:	MCP-105
Prototype test summary data sheet:	PTS-145
Standard set-mounted radiator cooling outline:	0500-3326
Optional set-mounted radiator cooling outline:	
Optional heat exchanger cooling outline:	
Optional remote radiator cooling outline:	

Fuel consumption	Standby				Prime				Continuous
	kW (kVA)				kW (kVA)				kW (kVA)
Ratings	500 (625)				455 (569)				
Load	1/4	1/2	3/4	Full	1/4	1/2	3/4	Full	Full
US gph	11.6	18.8	25.7	34.4	10.9	17.6	23.7	30.4	
L/hr	44	71	97	130	41	67	90	115	

Engine	Standby rating	Prime rating	Continuous rating
Engine manufacturer	Cummins Inc.		
Engine model	QSX15-G9		
Configuration	Cast iron with replaceable wet cylinder liners, in-line 6 cylinder		
Aspiration	Turbocharged with air-to-air charge air-cooling		
Gross engine power output, kWm (bhp)	563.0 (755.0)	507.3 (680.0)	
BMEP at set rated load, kPa (psi)	2433.9 (353.0)	2213.2 (321.0)	
Bore, mm (in.)	136.9 (5.39)		
Stroke, mm (in.)	168.9 (6.65)		
Rated speed, rpm	1800		
Piston speed, m/s (ft/min)	10.1 (1995.0)		
Compression ratio	17.0:1		
Lube oil capacity, L (qt)	83.3 (88.0)		
Overspeed limit, rpm	2150 ± 50		
Regenerative power, kW	52.00		

Fuel flow

	Standby rating	Prime rating	Continuous rating
Maximum fuel flow, L/hr (US gph)	423.9 (112.0)		
Maximum inlet restriction, mm Hg (in Hg)	127.0 (5.0)		
Maximum return restriction, mm Hg (in Hg)	165.1 (6.5)		

Air

Combustion air, m ³ /min (scfm)	41.6 (1470.0)	38.8 (1370.0)	
Maximum air cleaner restriction, kPa (in H ₂ O)	6.2 (25.0)		
Alternator cooling air, m ³ /min (scfm)	62.0 (1290.0)		

Exhaust

Exhaust flow at set rated load, m ³ /min (cfm)	102.6 (3625.0)	88.7 (3135.0)	
Exhaust temperature, °C (°F)	482.8 (901.0)	466.7 (872.0)	
Maximum back pressure, kPa (in H ₂ O)	10.2 (41.0)		

Standard set-mounted radiator cooling

Ambient design, °C (°F)	40 (104)		
Fan load, kW _m (HP)	19 (25.5)		
Coolant capacity (with radiator), L (US gal)	57.9 (15.3)		
Cooling system air flow, m ³ /min (scfm)	707.5 (25000.0)		
Total heat rejection, MJ/min (Btu/min)	19.6 (18485.0)	17.7 (16680.0)	
Maximum cooling air flow static restriction, kPa (in H ₂ O)	0.12 (0.5)		

Optional set-mounted radiator cooling

Ambient design, °C (°F)	50 (122)		
Fan load, kW _m (HP)	19 (25.5)		
Coolant capacity (with radiator), L (US gal)	57.9 (15.3)		
Cooling system air flow, m ³ /min (scfm)	707.5 (25000.0)		
Total heat rejection, MJ/min (Btu/min)	19.6 (18485.0)	17.7 (16680.0)	
Maximum cooling air flow static restriction, kPa (in H ₂ O)	0.12 (0.5)		

Optional heat exchanger cooling

Set coolant capacity, L (US Gal.)			
Heat rejected, jacket water circuit, MJ/min (Btu/min)			
Heat rejected, after-cooler circuit, MJ/min (Btu/min)			
Heat rejected, fuel circuit, MJ/min (Btu/min)			
Total heat radiated room, MJ/min (Btu/min)			
Maximum raw water pressure, jacket water circuit, kPa (psi)			
Maximum raw water pressure, after-cooler circuit, kPa (psi)			
Maximum raw water pressure, fuel circuit, kPa (psi)			
Maximum raw water flow, jacket water circuit, L/min (US gal/min)			
Maximum raw water flow, after-cooler circuit, L/min (US gal/min)			
Maximum raw water flow, fuel circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, jacket water circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, after-cooler circuit, L/min (US gal/min)			
Minimum raw water flow at 27 °C (80 °F) inlet temp, fuel circuit, L/min (US gal/min)			

Optional heat exchanger cooling (continued)

Raw water delta P at min flow, jacket water circuit, kPa (psi)			
Raw water delta P at min flow, after-cooler circuit, kPa (psi)			
Raw water delta P at min flow, fuel circuit, kPa (psi)			
Maximum jacket water outlet temp, °C (°F)			
Maximum after-cooler inlet temp, °C (°F)			
Maximum after-cooler inlet temp at 25 °C (77 °F) ambient, °C (°F)			

Optional remote radiator cooling¹

Set coolant capacity, L (US gal)	
Max flow rate at max friction head, jacket water circuit, L/min (US gal/min)	
Max flow rate at max friction head, after-cooler circuit, L/min (US gal/min)	
Heat rejected, jacket water circuit, MJ/min (Btu/min)	
Heat rejected, after-cooler circuit, MJ/min (Btu/min)	
Heat rejected, fuel circuit, MJ/min	
Total heat radiated to room, MJ/min (Btu/min)	
Maximum friction head, jacket water circuit, kPa (psi)	
Maximum friction head, after-cooler circuit, kPa (psi)	
Maximum static head, jacket water circuit, m (ft)	
Maximum static head, after-cooler circuit, m (ft)	
Maximum jacket water outlet temp, °C (°F)	
Maximum after-cooler inlet temp at 25 °C (77 °F) ambient, °C (°F)	
Maximum after-cooler inlet temp, °C (°F)	
Maximum fuel flow, L/hr (US gph)	
Maximum fuel return line restriction, kPa (in Hg)	

Weights²

Unit dry weight kgs (lbs)	4325 (9535)
Unit wet weight kgs (lbs)	4461 (9835)

Notes:

¹ For non-standard remote installations contact your local Cummins representative.

² Weights represent a set with standard features. See outline drawing for weights of other configurations.

Derating factors

Standby	<p>Genset may be operated at up to 1400 m (4593 ft) and 40°C (104°F) without power deration. For sustained operation above these conditions, derate by 3.1% per 305 m (1000 ft), and 9% per 10°C (9% per 18°F).</p> <p>Genset may be operated at up to 500 m (1640 ft) and 50°C (122°F) without power deration. For sustained operation above these conditions, derate by 3% per 305 m (1000 ft), and 9.5% per 10°C (9% per 18°F).</p>
Prime	<p>Genset may be operated at up to 2250 m (7382 ft) and 40°C (104°F) without power deration. For sustained operation above these conditions, derate by 3.2% per 305 m (1000 ft), and 16.6% per 10°C (16.6% per 18°F).</p> <p>Genset may be operated at up to 1600 m (5249 ft) and 50°C (122°F) without power deration. For sustained operation above these conditions, derate by 3.2% per 305 m (1000 ft), and 16.6% per 10°C (16.6% per 18°F).</p>
Continuous	

Ratings definitions

Emergency Standby Power (ESP):	Limited-Time Running Power (LTP):	Prime Power (PRP):	Base Load (Continuous) Power (COP):
Applicable for supplying power to varying electrical load for the duration of power interruption of a reliable utility source. Emergency Standby Power (ESP) is in accordance with ISO 8528. Fuel stop power in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power to a constant electrical load for limited hours. Limited-Time Running Power (LTP) is in accordance with ISO 8528.	Applicable for supplying power to varying electrical load for unlimited hours. Prime Power (PRP) is in accordance with ISO 8528. Ten percent overload capability is available in accordance with ISO 3046, AS 2789, DIN 6271 and BS 5514.	Applicable for supplying power continuously to a constant electrical load for unlimited hours. Continuous Power (COP) is in accordance with ISO 8528, ISO 3046, AS 2789, DIN 6271 and BS 5514.

Alternator data

Three phase table ¹		105 °C	105 °C	105 °C	125 °C	125 °C	125 °C	125 °C	125 °C	150 °C	150 °C	150 °C	150 °C
Feature code		B262	B301	B252	B258	B252	B414	B246	B300	B426	B413	B424	B419
Alternator data sheet number		308	307	307	308	307	308	306	306	307	307	305	306
Voltage ranges		110/190 thru 139/240 220/380 thru 277/480	347/600	120/208 thru 139/240 240/416 thru 277/480	110/190 thru 139/240 220/380 thru 277/480	120/208 thru 139/240 240/416 thru 277/480	120/208 thru 139/240 240/416 thru 277/480	277/480	347/600	110/190 thru 139/240 220/380 thru 277/480	120/208 thru 139/240 240/416 thru 277/480	277/480	347/600
Surge kW		514	517	514	514	514	516	515	515	512	514	512	515
Motor starting kVA (at 90% sustained voltage)	Shunt												
	PMG	2429	2208	2208	2429	2208	2429	1896	1896	2208	2208	1749	1896
Full load current - amps at Standby rating		<u>110/190</u> 1901	<u>120/208</u> 1737	<u>110/220</u> 1642	<u>115/230</u> 1571	<u>139/240</u> 1505	<u>220/380</u> 951	<u>230/400</u> 903	<u>240/416</u> 868	<u>255/440</u> 821	<u>277/480</u> 753	<u>347/600</u> 602	

Note:

¹ Single phase power can be taken from a three phase generator set at up to 40% of the generator set nameplate kW rating at unity power factor.

Formulas for calculating full load currents:

Three phase output

Single phase output

$$\frac{\text{kW} \times 1000}{\text{Voltage} \times 1.73 \times 0.8} \qquad \frac{\text{kW} \times \text{SinglePhaseFactor} \times 1000}{\text{Voltage}}$$

Warning: Back feed to a utility system can cause electrocution and/or property damage. Do not connect to any building's electrical system except through an approved device or after building main switch is open.

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PowerCommand®

2.3 Control System



Control System Description

The PowerCommand control system is a microprocessor-based generator set monitoring, metering and control system designed to meet the demands of today's engine driven generator sets. The integration of all control functions into a single control system provides enhanced reliability and performance, compared to conventional generator set control systems. These control systems have been designed and tested to meet the harsh environment in which gensets are typically applied.

Features

- 320 x 240 pixels graphic LED backlight LCD.
- Multiple language support.
- AmpSentry™ protective relay - true alternator overcurrent protection.
- Real time clock for fault and event time stamping.
- Exerciser clock and time of day start/stop.
- Digital voltage regulation. Three phase full wave FET type regulator compatible with either shunt or PMG systems.
- Generator set monitoring and protection.
- 12 and 24 VDC battery operation.
- Modbus® interface for interconnecting to customer equipment.
- Warranty and service. Backed by a comprehensive warranty and worldwide distributor service network.
- Certifications - suitable for use on generator sets that are designed, manufactured, tested and certified to relevant UL, NFPA, ISO, IEC, Mil Std., CE and CSA standards.

PowerCommand Digital Genset Control PCC 2300



Description

The PowerCommand generator set control is suitable for use on a wide range of generator sets in non-paralleling applications. The PowerCommand control is compatible with shunt or PMG excitation style. It is suitable for use with reconnectable or non-reconnectable generators, and it can be configured for any frequency, voltage and power connection from 120-600 VAC Line-to-Line.

Power for this control system is derived from the generator set starting batteries. The control functions over a voltage range from 8 VDC to 30 VDC.

Features

- 12 and 24 VDC battery operation.
- Digital voltage regulation - Three phase full wave FET type regulator compatible with either shunt or PMG systems. Sensing is three phase.
- Full authority engine communications (where applicable) - Provides communication and control with the Engine
- due to thermal Control Module (ECM).
- AmpSentry™ protection provides industry-leading alternator overcurrent protection:
 - Time-based generator protection applicable to both line-to-line and line-to-neutral, that can detect an unbalanced fault condition and swiftly react appropriately. Balanced faults can also be detected by AmpSentry and appropriate acted upon.
- Reduces the risk of Arc Flash overload or electrical faults by inverse time protection
- Common harnessing - with higher feature Cummins controls. Allows for easy field upgrades.
- Generator set monitoring - Monitors status of all critical engine and alternator functions.
- Digital genset metering (AC and DC).
- Genset battery monitoring system to sense and warn against a weak battery condition.
- Configurable for single or three phase AC metering.
- Engine starting - Includes relay drivers for starter, Fuel Shut Off (FSO), glow plug/spark ignition power and switch B+ applications.
- Generator set protection – Protects engine and alternator.
- Real time clock for fault and event time stamping.
- Exerciser clock and time of day start/stop.
- Advanced serviceability - using InPower™, a PC-based software service tool.

- Environmental protection - The control system is designed for reliable operation in harsh environments. The main control board is a fully encapsulated module that is protected from the elements.
- Modbus interface for interconnecting to customer equipment.
- Configurable inputs and outputs - Four discrete inputs and four dry contact relay outputs.
- Warranty and service - Backed by a comprehensive warranty and worldwide distributor service network.
- Certifications - Suitable for use on generator sets that are designed, manufactured, tested and certified to relevant UL, NFPA, ISO, IEC, Mil Std., CE and CSA standards.

Base Control Functions

HMI Capability

Operator adjustments - The HMI includes provisions for many set up and adjustment functions.

Generator set hardware data - Access to the control and software part number, generator set rating in kVA and generator set model number is provided from the HMI or InPower.

Data logs - Includes engine run time, controller on time, number of start attempts, total kWh, and load profile (control logs data indicating the operating hours at percent of rated kW load, in 5% increments. The data is presented on the operation panel based on total operating hours on the generator.)

Fault history - Provides a record of the most recent fault conditions with control date and time stamp. Up to 32 events are stored in the control non-volatile memory.

Alternator data

- Voltage (single or three phase Line-to-Line and Line-to-Neutral)
- Current (single or three phase)
- kW, kVar, power factor, kVA (three phase and total)
- Frequency

AmpSentry: 3x current regulation for downstream tripping/motor inrush management. Thermal damage curve (3-phase short) or fixed timer (2 sec for 1- Phase Short or 5 sec for 2-Phase short).

Engine data

- Starting battery voltage
- Engine speed
- Engine temperature
- Engine oil pressure
- Engine oil temperature
- Intake manifold temperature
- Comprehensive Full Authority Engine (FAE) data (where applicable)

Service adjustments - The HMI includes provisions for adjustment and calibration of generator set control functions. Adjustments are protected by a password. Functions include:

Service adjustments (continued)

- Engine speed governor adjustments
- Voltage regulation adjustments
- Cycle cranking
- Configurable fault set up
- Configurable output set up
- Meter calibration
- Display language and units of measurement

Engine Control

SAE-J1939 CAN interface to full authority ECMs (where applicable). Provides data swapping between genset and engine controller for control, metering and diagnostics.

12 VDC/24 VDC battery operations - PowerCommand will operate either on 12 VDC or 24 VDC batteries.

Temperature dependent governing dynamics (with electronic governing) - modifies the engine governing control parameters as a function of engine temperature. This allows the engine to be more responsive when warm and more stable when operating at lower temperature levels.

Isochronous governing - (where applicable) Capable of controlling engine speed within +/-0.25% for any steady state load from no load to full load. Frequency drift will not exceed +/-0.5% for a 33 °C (60 °F) change in ambient temperature over an 8 hour period.

Droop electronic speed governing - Control can be adjusted to droop from 0 to 10% from no load to full load.

Remote start mode - It accepts a ground signal from remote devices to automatically start the generator set and immediately accelerate to rated speed and voltage. The remote start signal will also wake up the control from sleep mode. The control can incorporate a time delay start and stop.

Remote and local emergency stop - The control accepts a ground signal from a local (genset mounted) or remote (facility mounted) emergency stop switch to cause the generator set to immediately shut down. The generator set is prevented from running or cranking with the switch engaged. If in sleep mode, activation of either emergency stop switch will wakeup the control.

Sleep mode - The control includes a configurable low current draw state to minimize starting battery current draw when the genset is not operating. The control can also be configured to go into a low current state while in auto for prime applications or applications without a battery charger.

Engine starting - The control system supports automatic engine starting. Primary and backup start disconnects are achieved by one of two methods: magnetic pickup or main alternator output frequency. The control also supports configurable glow plug control when applicable.

Cycle cranking - Is configurable for the number of starting cycles (1 to 7) and duration of crank and rest periods. Control includes starter protection algorithms to prevent the operator from specifying a starting sequence that might be damaging.

Time delay start and stop (cooldown) - Configurable for time delay of 0-300 seconds prior to starting after receiving a remote start signal and for time delay of 0-600 seconds prior to shut down after signal to stop in normal operation modes. Default for both time delay periods is 0 seconds.

Alternator Control

The control includes an integrated three phase Line-to-Line sensing voltage regulation system that is compatible with shunt or PMG excitation systems. The voltage regulation system is a three phase full wave rectified and has an FET output for good motor starting capability.

Major system features include:

Digital output voltage regulation - Capable of regulating output voltage to within +/-1.0% for any loads between no load and full load. Voltage drift will not exceed +/- 1.5% for a 40 °C (104 °F) change in temperature in an eight hour period. On engine starting or sudden load acceptance, voltage is controlled to a maximum of 5% overshoot over nominal level. The automatic voltage regulator feature can be disabled to allow the use of an external voltage regulator.

Droop voltage regulation - Control can be adjusted to droop from 0-10% from no load to full load.

Torque-matched V/Hz overload control - The voltage roll-off set point and rate of decay (i.e. the slope of the V/Hz curve) is adjustable in the control.

Fault current regulation - PowerCommand will regulate the output current on any phase to a maximum of three times rated current under fault conditions for both single phase and three phase faults. In conjunction with a permanent magnet generator, it will provide three times rated current on all phases for motor starting and short circuit coordination purpose.

Protective Functions

On operation of a protective function the control will indicate a fault by illuminating the appropriate status LED on the HMI, as well as display the fault code and fault description on the LCD. The nature of the fault and time of occurrence are logged in the control. The service manual and InPower service tool provide service keys and procedures based on the service codes provided.

Protective functions include:

Battle Short Mode

When enabled and the *battle short* switch is active, the control will allow some shutdown faults to be bypassed. If a bypassed shutdown fault occurs, the fault code and description will still be annunciated, but the genset will not shutdown. This will be followed by a *fail to shutdown* fault. Emergency stop shutdowns and others that are critical for proper operation are not bypassed. Please refer to the control application guide or manual for list of these faults.

Derate

The derate function reduces output power of the genset in response to a fault condition. If a derate command occurs while operating on an isolated bus, the control will issue commands to reduce the load on the genset via contact closures or modbus.

Configurable Alarm and Status Inputs

The control accepts up to four alarm or status inputs (configurable contact closed to ground or open) to indicate a configurable (customer-specified) condition. The control is programmable for warning, shutdown or status indication and for labeling the input.

Emergency Stop

Annunciated whenever either emergency stop signal is received from external switch.

Full Authority Electronic Engine Protection

Engine fault detection is handled inside the engine ECM. Fault information is communicated via the SAE-J1939 data link for annunciation in the HMI.

General Engine Protection

Low and high battery voltage warning - Indicates status of battery charging system (failure) by continuously monitoring battery voltage.

Weak battery warning - The control system will test the battery each time the generator set is signaled to start and indicate a warning if the battery indicates impending failure.

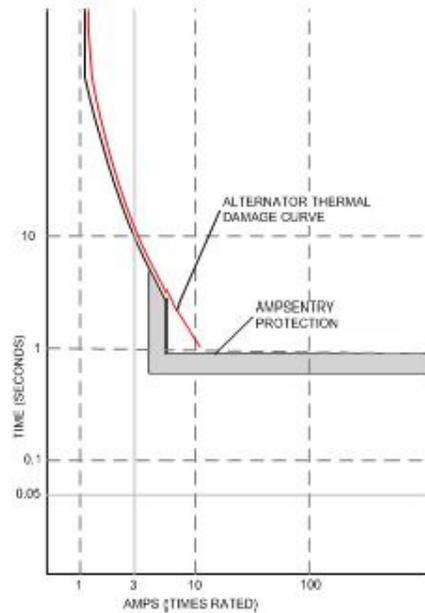
Fail to start (overcrank) shutdown - The control system will indicate a fault if the generator set fails to start by the completion of the engine crank sequence.

Fail to crank shutdown - Control has signaled starter to crank engine but engine does not rotate.

Cranking lockout - The control will not allow the starter to attempt to engage or to crank the engine when the engine is rotating.

Alternator Protection

AmpSentry protective relay - A comprehensive monitoring and control system integral to the PowerCommand Control System that guards the electrical integrity of the alternator and power system by providing protection against a wide array of fault conditions in the generator set or in the load. It also provides single and three phase fault current regulation so that downstream protective devices have the maximum current available to quickly clear fault conditions without subjecting the alternator to potentially catastrophic failure conditions. Thermal damage curve (3-Phase short) or fixed timer (2 sec for 1-Phase short, 5 sec for 2-Phase short). See document R1053 for a full-size time over current curve.



AmpSentry Maintenance Mode (AMM) - Instantaneous tripping, if AmpSentry Maintenance mode is active (50mS response to turn off AVR excitation/shutdown genset) for arc flash reduction when personnel are near genset.

High AC voltage shutdown (59) - Output voltage on any phase exceeds preset values. Time to trip is inversely proportional to amount above threshold. Values adjustable from 105-125% of nominal voltage, with time delay adjustable from 0.1-10 seconds. Default value is 110% for 10 seconds.

Low AC voltage shutdown (27) - Voltage on any phase has dropped below a preset value. Adjustable over a range of 50-95% of reference voltage, time delay 2-20 seconds. Default value is 85% for 10 seconds. Function tracks reference voltage. Control does not nuisance trip when voltage varies due to the control directing voltage to drop, such as during a V/Hz roll-off during synchronizing.

Under frequency shutdown (81 u) - Generator set output frequency cannot be maintained. Settings are adjustable from 2-10 Hz below reference governor set point, for a 5-20 second time delay. Default: 6 Hz, 10 seconds.

Under frequency protection is disabled when excitation is switched off, such as when engine is operating in idle speed mode.

Over frequency shutdown/warning (81 o) - Generator set is operating at a potentially damaging frequency level. Settings are adjustable from 2-10 Hz above nominal governor set point for a 1-20 second time delay. Default: 6 Hz, 20 seconds, disabled.

Overcurrent warning/shutdown - Thresholds and time delays are configurable. Implementation of the thermal damage curve with instantaneous trip level calculated based on current transformer ratio and application power rating.

Loss of sensing voltage shutdown - Shutdown of generator set will occur on loss of voltage sensing inputs to the control.

Field overload shutdown - Monitors field voltage to shutdown generator set when a field overload condition occurs.

Over load (kW) warning - Provides a warning indication when engine is operating at a load level over a set point.

Adjustment range: 80-140% of application rated kW, 0-120 second delay. Defaults: 105%, 60 seconds.

Reverse power shutdown (32) - Adjustment range: 5-20% of standby kW rating, delay 1-15 seconds. Default: 10%, 3 seconds.

Reverse Var shutdown - Shutdown level is adjustable: 15-50% of rated Var output, delay 10-60 seconds. Default: 20%, 10 seconds.

Short circuit protection - Output current on any phase is more than 175% of rating and approaching the thermal damage point of the alternator. Control includes algorithms to protect alternator from repeated over current conditions over a short period of time.

Field Control Interface

Input signals to the PowerCommand control include:

- Coolant level (where applicable)
- Fuel level (where applicable)
- Remote emergency stop
- Remote fault reset
- Remote start
- Battleshort
- Rupture basin
- Start type signal
- Configurable inputs - Control includes (4) input signals from customer discrete devices that are configurable for warning, shutdown or status indication, as well as message displayed

Output signals from the PowerCommand control include:

- Load dump signal: Operates when the generator set is in an overload condition.
- Delayed off signal: Time delay based output which will continue to remain active after the control has removed the run command. Adjustment range: 0 – 120 seconds. Default: 0 seconds.

- Configurable relay outputs: Control includes (4) relay output contacts (3 A, 30 VDC). These outputs can be configured to activate on any control warning or shutdown fault as well as ready to load, not in auto, common alarm, common warning and common shutdown.

- Ready to load (generator set running) signal: Operates when the generator set has reached 90% of rated speed and voltage and latches until generator set is switched to off or idle mode.

Communications Connections Include:

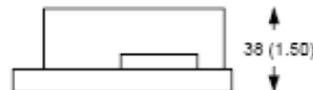
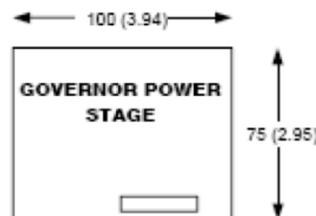
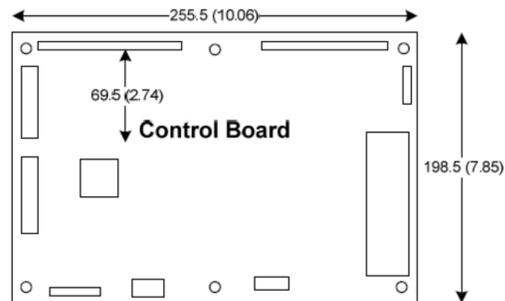
- PC tool interface: This RS-485 communication port allows the control to communicate with a personal computer running InPower software.

- Modbus RS-485 port: Allows the control to communicate with external devices such as PLCs using Modbus protocol.

Note - An RS-232 or USB to RS-485 converter is required for communication between PC and control.

- Networking: This RS-485 communication port allows connection from the control to the other Cummins products.

Mechanical Drawings



PowerCommand Human Machine Interface HMI320



Description

This control system includes an intuitive operator interface panel that allows for complete genset control as well as system metering, fault annunciation, configuration and diagnostics. The interface includes five genset status LED lamps with both internationally accepted symbols and English text to comply with customer's needs. The interface also includes an LED backlit LCD display with tactile feel soft-switches for easy operation and screen navigation. It is configurable for units of measurement and has adjustable screen contrast and brightness.

The *run/off/auto* switch function is integrated into the interface panel.

All data on the control can be viewed by scrolling through screens with the navigation keys. The control displays the current active fault and a time-ordered history of the five previous faults.

Features

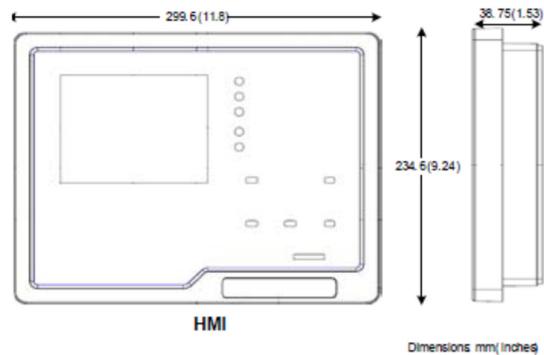
- LED indicating lamps:
 - Genset running
 - Remote start
 - Not in auto
 - Shutdown
 - Warning
 - Auto
 - Manual and stop
- 320 x 240 pixels graphic LED backlight LCD.
- Four tactile feel membrane switches for LCD defined operation. The functions of these switches are defined dynamically on the LCD.
- Seven tactile feel membrane switches dedicated screen navigation buttons for up, down, left, right, ok, home and cancel.
- Six tactile feel membrane switches dedicated to control for auto, stop, manual, manual start, fault reset and lamp test/panel lamps.

- Two tactile feel membrane switches dedicated to control of circuit breaker (where applicable).
- Allows for complete genset control setup.
- Certifications: Suitable for use on generator sets that are designed, manufactured, tested and certified to relevant UL, NFPA, ISO, IEC, Mil Std., CE and CSA standards.
- LCD languages supported: English, Spanish, French, German, Italian, Greek, Dutch, Portuguese, Finnish, Norwegian, Danish, Russian and Chinese Characters.

Communications connections include:

- PC tool interface - This RS-485 communication port allows the HMI to communicate with a personal computer running InPower.
- This RS-485 communication port allows the HMI to communicate with the main control board.

Mechanical Drawing



Software

InPower (beyond 6.5 version) is a PC-based software service tool that is designed to directly communicate to PowerCommand generator sets and transfer switches, to facilitate service and monitoring of these products.

Environment

The control is designed for proper operation without recalibration in ambient temperatures from -40 °C to +70 °C (-40 °F to 158 °F) and for storage from -55 °C to +80 °C (-67 °F to 176 °F). Control will operate with humidity up to 95%, non-condensing.

The HMI is designed for proper operation in ambient temperatures from -20 °C to +70 °C (-4 °F to 158 °F) and for storage from -30 °C to +80 °C (-22 °F to 176 °F).

The control board is fully encapsulated to provide superior resistance to dust and moisture. Display panel has a single membrane surface, which is impervious to effects of dust, moisture, oil and exhaust fumes. This panel uses a sealed membrane to provide long reliable service life in harsh environments.

The control system is specifically designed and tested for resistance to RFI/EMI and to resist effects of vibration to provide a long reliable life when mounted on a generator set. The control includes transient voltage surge suppression to provide compliance to referenced standards.

Certifications

PowerCommand meets or exceeds the requirements of the following codes and standards:

- NFPA 110 for level 1 and 2 systems.
- ISO 8528-4: 1993 compliance, controls and switchgear.
- CE marking: The control system is suitable for use on generator sets to be CE-marked.
- EN50081-1,2 residential/light industrial emissions or industrial emissions.
- EN50082-1,2 residential/light industrial or industrial susceptibility.
- ISO 7637-2, level 2; DC supply surge voltage test.
- Mil Std 202C, Method 101 and ASTM B117: Salt fog test.
- UL 6200 recognized and suitable for use on UL 2200 Listed generator sets.
- CSA C282-M1999 compliance
- CSA 22.2 No. 14 M91 industrial controls.
- PowerCommand control systems and generator sets are designed and manufactured in ISO 9001 certified facilities.

Warranty

All components and subsystems are covered by an express limited one year warranty. Other optional and extended factory warranties and local distributor maintenance agreements are available.



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Alternator data sheet

Frame size: **HC5D**

Characteristics								
Weights:	Wound stator assembly:	1433 lb		650 kg				
	Rotor assembly:	1190 lb		536 kg				
	Complete assembly:	3090 lb		1392 kg				
Maximum speed:		2250 rpm						
Excitation current:	Full load:	1.72 Amps						
	No load:	0.40 Amps						
Insulation system:	Class H throughout							
3 ϕ Ratings (0.8 power factor)		60 Hz (winding no)				50 Hz (winding no)		
(Based on specific temperature rise at 40 °C ambient temperature)		<u>110/190</u> <u>220/380</u> (311/312)	<u>120/208</u> <u>240/416</u> (311/312)	<u>139/240</u> <u>277/480</u> (311/312)	<u>347/600</u> (07/17)	<u>110/190</u> <u>220/380</u> (311/312)	<u>120/208</u> <u>240/415</u> (311/312)	<u>127/220</u> <u>254/440</u> (311/312)
150 °C Rise ratings	kW	428	470	540	540	412	412	412
	kVA	535	588	675	515	515	515	515
125 °C Rise ratings	kW	420	460	515	515	400	400	400
	kVA	525	775	644	644	500	500	500
105 °C Rise ratings	kW	376	415	470	470	360	360	360
	kVA	470	519	588	588	450	450	450
80 °C Rise ratings	kW	328	360	412	412	312	312	312
	kVA	410	450	515	515	390	390	390
Reactances (per unit $\pm 10\%$)		<u>110/190</u> <u>220/380</u>	<u>120/208</u> <u>240/416</u>	<u>139/240</u> <u>277/480</u>	<u>347/600</u>	<u>110/190</u> <u>220/380</u>	<u>120/208</u> <u>240/415</u>	<u>127/220</u> <u>254/440</u>
(Based on full load at 125 °C rise rating)								
Synchronous		3.85	3.52	2.96	2.96	3.02	2.53	2.25
Transient		0.18	0.17	0.14	0.14	0.16	0.14	0.12
Subtransient		0.13	0.12	0.10	0.10	0.11	0.10	0.08
Negative sequence		0.25	0.23	0.19	0.19	0.19	0.16	0.14
Zero sequence		0.11	0.10	0.09	0.09	0.09	0.08	0.07
Motor starting		<u>Broad range</u>			<u>600</u>	<u>Broad range</u>		
Maximum kVA	(90% sustained voltage)	1896			1896	1443		
Time constants (sec)		<u>Broad range</u>			<u>600</u>	<u>Broad range</u>		
Transient		0.080			0.080	0.080		
Subtransient		0.012			0.012	0.012		
Open circuit		2.200			2.200	2.200		
DC		0.018			0.018	0.018		
Windings (@ 20 °C)		<u>Broad range</u>			<u>600</u>	<u>Broad range</u>		
Stator resistance	(Ohms per phase)	0.0116			0.0158	0.0116		
Rotor resistance	(Ohms)	1.7700			1.7700	1.7700		
Number of leads		12			6	12		

Single phase power can be taken up to 40% of 3 phase-ratings



Data Sheet

Circuit Breakers

Description

This Data sheet provides circuit breaker manufacturer part numbers and specifications. The Circuit breaker box description is the rating of that breaker box installation on a Cummins Generator. Please refer to the website of the circuit breaker manufacturer for breaker specific ratings and technical information.

Applicable Models

Engine	Models					
Kubota	C10D6	C15D6	C20D6			
QJSJ2.4	C20N6	C25N6	C30N6	C30N6H	C36N6	C36N6H
	C40N6	C40N6H	C50N6H	C60N6H		
B3.3	C25D6	C30D6	C35D6	C40D6	C50D6	C60D6
QJSJ5.9G	C45N6	C50N6	C60N6	C70N6	C80N6	C100N6
QJSJ8.9G	C125N6	C150N6				
QSB5	DSFAC	DSFAD	DSFAE	C50D6C	C60D6C	C80D6C
	C100D6C	C125D6C				
QSB7	DSGAA	DSGAB	DSGAC	DSGAD	DSGAE	
		C125D6D	C150D6D	C175D6D	C200D6D	
QSL9	DSHAD	DQDAA	DQDAB	DQDAC		
QSM11	DQHAB					
QSX15	DFEJ	DFEK				

Instructions

1. Locate the circuit breaker feature code or part number and use the charts below to find the corresponding manufacturer circuit breaker catalog number.
2. Use the first letter of the circuit breaker catalog number to determine the "frame" of the breaker. If the first letter is an "N", use the second letter. Then follow the corresponding website link from the table below to find the breaker catalog number description.

Please refer to the catalog numbering systems page, which is given in the chart, to understand the nomenclature of the catalog number.

Frame	Catalog name*	Catalog number description page(s)
P	0612CT0101 http://www.schneider-electric.us/en/download/document/0612CT0101/	16-17
H, J, and L	0611CT1001 http://www.schneider-electric.us/en/download/document/0611CT1001/	8-9
Q	0734CT0201 http://www.schneider-electric.us/en/download/document/0734CT0201/	4

*The following link may also be used to search specifically by the breaker part number or for the catalog name listed above. <http://products.schneider-electric.us/technical-library/>

3. Search the catalog by using the first 3 letters of the breaker catalog number and the first 5 numbers to find information such as trip curves, accessories, and dimensional details regarding the circuit breaker.

*If the catalog number starts with "N", skip the N and begin your search with the second letter.

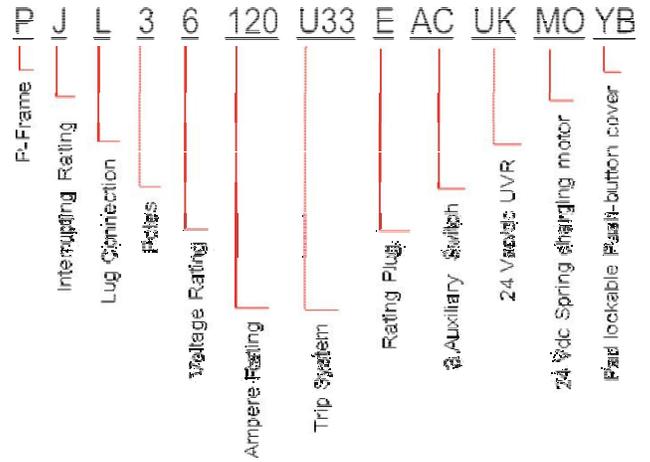
*If the first 3 letters are "PJP," the search will not work. You will need to start with just "PJ" and use the description pages to obtain the information you are looking for on the "PJP."

Example

After finding your circuit breaker catalog number to be "PJL36120U33EACUKMOYB," navigate to the P-frame catalog by using the link provided.

Look at pages 16-17 of the pdf catalog to find the nomenclature of the breaker.

Search the P-frame spec sheet using the search "PJL36120."



Mechanically Operated Breakers						
Feature Code	Breaker Box Description	Cummins Part #	Manufacturer	Breaker Catalog Number	Trip Unit	Plug Type
KC60-2	Circuit Breaker-1200A,Right CB on Right side,3-Pole, UL 600,IEC 690, 100%	0320-2183	Schneider Electric	PJP36120U31E	MicroLogic 3.0 LI	E
KC61-2	Circuit Breaker-1200A,Left CB on Right side,3-Pole, UL 600,IEC 690, 100%	0320-2183	Schneider Electric	PJP36120U31E	MicroLogic 3.0 LI	E
KC62-2	Circuit Breaker-800A,Right CB on Right side,3-Pole,UL 600,IEC 690 100%	0320-2182	Schneider Electric	PJP36080U31F	MicroLogic 3.0 LI	F
KC63-2	Circuit Breaker-800A,Left CB on Right side,3-Pole, UL 600,IEC 690 100%	0320-2182	Schneider Electric	PJP36080U31F	MicroLogic 3.0 LI	F
KC64-2	Circuit Breaker-600A,Right CB on Right side,3-Pole, UL 600,IEC 690, 100%	A044T468	Schneider Electric	NLGL36600U33X-600A	MicroLogic 3.3S	N/A
KC65-2	Circuit Breaker-600A,Left CB on Right side,3-Pole, UL 600,IEC 690, 100%	A044T468	Schneider Electric	NLGL36600U33X-600A	MicroLogic 3.3S	N/A
KC66-2	Circuit Breaker-400A,Right CB on Right side,3-Pole,UL 600,IEC 690 100%	A045U083	Schneider Electric	NLGL36400U33XLY-400A	MicroLogic 3.3S	N/A
KC67-2	Circuit Breaker-400A,Left CB on Right side,3-Pole, UL 600,IEC 690 100%	A045U083	Schneider Electric	NLGL36400U33XLY-400A	MicroLogic 3.3S	N/A
KS80-2	CircuitBreaker-15A,Right,3P,600VAC,80%,UL	0320-2346-72	Schneider Electric	HGL36015	Thermal Magnetic	N/A
KS81-2	CircuitBreaker-15A,Left,3P,600VAC,80%,UL	0320-2346-72A	Schneider Electric	HGL36015	Thermal Magnetic	N/A
KS84-2	CircuitBreaker-20A,Right,3P,600VAC,80%,UL	0320-2346-71	Schneider Electric	HGL36020	Thermal Magnetic	N/A
KS85-2	CircuitBreaker-20A,Left,3P,600VAC,80%,UL	0320-2346-71A	Schneider Electric	HGL36020	Thermal Magnetic	N/A
KS88-2	CircuitBreaker-30A,Right,3P,600VAC,80%,UL	0320-2346-70	Schneider Electric	HGL36030	Thermal Magnetic	N/A
KS89-2	CircuitBreaker-30A,Left,3P,600VAC,80%,UL	0320-2346-70A	Schneider Electric	HGL36030	Thermal Magnetic	N/A
KS94-2	CircuitBreaker-40A,Right,3P,600VAC,80%,UL	0320-2346-69	Schneider Electric	HGL36040	Thermal Magnetic	N/A
KS95-2	CircuitBreaker-40A,Left,3P,600VAC,80%,UL	0320-2346-69A	Schneider Electric	HGL36040	Thermal Magnetic	N/A



Battery Charger

A048G602 10 A 50/60 Hz
A051H785 20 A 50/60 Hz



Description

Cummins® fully automatic battery chargers are constant voltage/constant current chargers incorporating a 4-stage charging algorithm. Designed for use in applications where battery life and reliability are important; these chargers, complete with built-in equalize charge capability, are ideal for stationary or portable starting battery charging service.

To achieve optimum battery life, a 4-stage charging cycle is implemented. The four charging stages are constant current, high-rate taper charge, finishing charge, and maintaining charge. During the constant current cycle the charger operates at maximum possible output in the fast charge mode. During the high-rate taper charge cycle the charger stays at fast charge voltage level until battery current acceptance falls to a portion of the charger's rated output. During the finishing charge cycle the charger operates at the float voltage and completes the battery charge. During the maintaining charge cycle the charger supplies only a few milliamps required by the battery to stay at peak capability.

An optional temperature sensor (A043D534) may be used to adjust charging voltage based on temperature of the battery. Use of a battery temperature sensor helps to increase battery life by preventing over or under charging. The battery temperature sensor also protects the battery from overheating. Temperature compensation sensor is required for all applications when battery charger and battery are located in different temperature or battery heater is being used.

Battery chargers are field-configurable for charging either 12 or 24 VDC battery systems at 50/60 Hz operation. Simple jumper selectors enable selection of output voltage and battery type.

Features

Protection – Surge protected to IEEE and EN standards. All models include single pole cartridge type fuses mounted on the printed circuit board to protect against input or output overcurrent.

Easy Installation – Clearly marked terminal blocks and panel knockouts provide convenient connections of input and output leads.

User Display – Output voltage and current, fault information and status are indicated on the front panel. Includes precision ammeter and voltmeter.

Monitoring – Status LED indicators are provided to show the condition of the charger. LED's on the right side of the monitor indicate operational functions for Temperature Compensation active (Green), AC on (Green), Float (Green) or Boost (Amber) mode, as well as Battery Fault (Red). LED's on the left side of the monitor illuminate (in Red) when Charger fail, High or Low VDC or AC fail occur.

Adjustable Float Voltage – Float voltage can be set, using easy to understand jumpers, for optimum battery performance and life.

Construction – NEMA-1 (IP20) corrosion resistant aluminium enclosure designed for wall mounting.

Faults – The charger senses and annunciates the following fault conditions: AC power loss, battery overvoltage, battery under voltage, battery fault conditions and charger failure. Includes an individual 30 volt/2 amp isolated contact for each alarm.

Vibration Resistant Design – complies with UL991 class B vibration resistance requirements.

Listed – C-UL listed to UL 1236 CSA standard 22.2 No 107.2-M89. Suited for flooded and AGM lead acid and NiCd batteries in generator set installations.

Warranty – 5 year CPG warranty.



Status and Fault LED



Field Selectable Jumper

Specifications

Performance and Physical Characteristics

Output:	Nominal voltage	12VDC* or 24VDC
	Float voltage – 12VDC batteries	12.87, 13.08, 13.31, 13.50*, 13.62, 14.30
	Float voltage – 24VDC batteries	25.74, 26.16, 26.62, 27.00*, 27.24, 28.60
	Equalize-voltage	6.5% above float voltage sensing
	Output voltage regulation	±0.5% (1/2%) line and load regulation
	Maximum output current	10 or 20 amps nominal
	Equalize charging	Battery interactive auto-boost
Input:	Voltage AC	120, 208, 240 ±10%
	Frequency	60/50 Hz +5%
Approximate net weight:		10A: 25 lbs. (11.36 Kg) 20A: 50 lbs. (22.68 Kg)
Approximate dimensions: height x width x depth-in		10A: 12.50" x 7.66" x 6.50"(318 x 195 x 165 mm) 20A: 13.06" x 13.95" x 6.83"(332 x 354 x 173 mm)
Ambient temperature operation: At full rated output -		- 4 °F to 104 °F (-20 °C to 45 °C)

Note:

- Battery charger comes with default settings of 12VDC and 13.50/27.00VDC float voltage and can be changed to the battery manufacture recommendations. Replacement printed circuit board and f uses are identified in the Owner's Manual (10A: A050S537 and 20A: A051X126) which resides in Quick Serve On-Line. Service parts can be purchased through the Memphis Distribution Center. The PC board replacement instruction sheet (10A: A052N073, 20A: A053W929) and service manual (A050D829) is also available.
- Installation and application must comply with "section 4.5.3 batteries and battery charger" of application guide T-030 (Liquid Cooled Generator Set Application Manual A040S369).

Caution:

- Higher input voltages (i.e. 480VAC or 600VAC) can be applied if a transformer with a 120VAC-240VAC output is installed. Higher input voltages (i.e. 480VAC or 600VAC) can be applied if a transformer with a 120VAC-240VAC output is installed. For voltages higher than 240 VAC, stepdown transformer must be used. Review the respective Owner/Installation manual A050S537 for 10Amp and A051X126 20A chargers for supplier recommended stepdown transformer requirements.
- 10Amp battery charger is recommended for genset applications with 1 or 2 factory provided batteries. 20Amp battery charger is recommended for Cummins Genset applications with 3 or 4 factory provided batteries. Please consider the auxiliary DC loads connected to the genset batteries and size this charger as per the T-030 application guide to prevent misapplication issues.
- Back feed to a utility system can cause electrocution and/or property damage. Do not connect generator sets to any building electrical system except through an approved device or after building main switch is open.
- For professional use only. Must be installed by a qualified service technician. Improper installation presents hazards of electrical shock and improper operation, resulting in severe personal injury and/or property damage.
- Use this charger for charging LEAD-ACID or LIQUID ELECTROLYTE NICKEL-CADMIUM batteries only. Do not use this battery charger for charging dry cells, alkaline, lithium, nickel-metal hydride, or sealed nickel-cadmium batteries that are commonly used with home appliances. These batteries may burst and cause injuries to persons and damage to property.
- Do not parallel these battery chargers with any other charging system.

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2020 EPA Tier 2 Exhaust Emission Compliance Statement 500DFEK Stationary Emergency 60 Hz Diesel Generator Set

Compliance Information:

The engine used in this generator set complies with Tier 2 emissions limit of U.S. EPA New Source Performance Standards for stationary emergency engines under the provisions of 40 CFR 60 Subpart IIII.

Engine Manufacturer: Cummins Inc.
 EPA Certificate Number: LCEXL015.AAJ-052
 Effective Date: 10/28/2019
 Date Issued: 10/28/2019
 EPA Engine Family (Cummins Emissions Family): LCEXL015.AAJ

Engine Information:

Model: QSX/QSX15/QSX15-G/QSX15-G9 Bore: 5.39 in. (137 mm)
 Engine Nameplate HP: 755 Stroke: 6.65 in. (169 mm)
 Type: 4 Cycle, In-line, 6 Cylinder Diesel Displacement: 912 cu. in. (15 liters)
 Aspiration: Turbocharged and CAC Compression ratio: 17.0:1
 Emission Control Device: Electronic Control Exhaust stack diameter: 8 in. (203 mm)

Diesel Fuel Emission Limits

D2 Cycle Exhaust Emissions

	Grams per BHP-hr			Grams per kWm-hr		
	<u>NO_x + NMHC</u>	<u>CO</u>	<u>PM</u>	<u>NO_x + NMHC</u>	<u>CO</u>	<u>PM</u>
Test Results	4.3	0.4	0.10	5.7	0.6	0.13
EPA Emissions Limit	4.8	2.6	0.15	6.4	3.5	0.20

Test methods: EPA emissions recorded per 40 CFR Part 60, 89, 1039, 1065 and weighted at load points prescribed in the regulations for constant speed engines.

Diesel fuel specifications: Cetane number: 40-50, Reference: ASTM D975 No. 2-D, 300-500 ppm Sulfur

Reference conditions: Air Inlet Temperature: 25 °C (77 °F), Fuel Inlet Temperature: 40 °C (104 °F). Barometric Pressure: 100 kPa (29.53 in Hg), Humidity: 10.7 g/kg (75 grains H₂O/lb) of dry air; required for NO_x correction, Restrictions: Intake Restriction set to a maximum allowable limit for clean filter; Exhaust Back Pressure set to a maximum allowable limit..

Tests conducted using alternate test methods, instrumentation, fuel or reference conditions can yield different results. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may result in elevated emission levels.



Sound data

500DFEK

60Hz Diesel

Sound pressure level @ 7 meters, dB(A)

See notes 1-8 listed below

Configuration		Measurement location number								Average
		1	2	3	4	5	6	7	8	
Standard – unhoused	Infinite exhaust	89	92	92	91	88	91	91	93	91
F183 – residential muffler	Mounted muffler	88	90	90	89	88	88	88	90	89
F200 – weather	Mounted muffler	91	90	85	88	89	88	85	91	89
F201 – quiet site II first stage	Mounted muffler	90	89	84	83	79	81	83	90	87
F202 – quiet site II second stage	Mounted muffler	71	73	71	72	73	74	74	73	73

Sound power level, dB(A)

See notes 2-6, 9, 10 listed below

Configuration		Octave band center frequency (Hz)								Overall sound power level
		63	125	250	500	1000	2000	4000	8000	
Standard – unhoused (note 3)	Infinite exhaust	82	98	104	109	112	113	111	113	119
F183 – residential muffler	Mounted muffler	105	114	115	111	108	108	102	101	119
F200 – weather	Mounted muffler	101	108	106	110	112	111	107	102	118
F201 – quiet site II first stage	Mounted muffler	101	108	105	108	111	109	106	99	116
F202 – quiet site II second stage	Mounted muffler	84	93	93	96	98	99	96	89	104

Exhaust sound power level, dB(A)

Open exhaust (no muffler) @ rated load	Octave band center frequency (Hz)								Overall sound power level
	63	125	250	500	1000	2000	4000	8000	
	103	119	125	123	125	126	127	121	133

Note:

- Position 1 faces the engine front. The positions proceed around the generator set in a counter-clockwise direction in 45° increments. All positions are at 7 m (23 ft) from the surface of the generator set and 1.2 m (48 in.) from floor level.
- Sound levels are subject to instrumentation, measurement, installation and manufacturing variability.
- Sound data with remote-cooled generator sets are based on rated loads without cooling fan noise.
- Sound levels for aluminum enclosures are approximately 2 dB(A)s higher than listed sound levels for steel enclosures.
- Sound data for generator set with infinite exhaust do not include exhaust noise.
- Data is based on full rated load with standard radiator-cooling fan package.
- Sound pressure levels are measured per ANSI S1.13 and ANSI S12.18, as applicable.
- Reference sound pressure is 20 µPa.
- Sound power levels per ISO 3744 and ISO 8528-10, as applicable.
- Reference power = 1 pw (10⁻¹²W).
- Exhaust sound power levels are per ISO 6798, as applicable.



Prototype Test Support (PTS) 60 Hz test summary



<u>Generator set models</u>	<u>Representative prototype</u>
450DFEJ 500DFEK	Model: 500DFEK Alternator: HC5F Engine: QSX15-G9

The following summarizes prototype testing conducted on the designated representative prototype of the specified models. This testing is conducted to verify the complete generator set electrical and mechanical design integrity. Prototype testing is conducted only on generator sets not sold as new equipment.

Maximum surge power: 516 kW
 The generator set was evaluated to determine the stated maximum surge power.

Maximum motor starting: 2429 kVA
 The generator set was tested to simulate motor starting by applying the specified kVA load at low lagging power factor (0.4 or lower). With this load applied, the generator set recovered to a minimum of 90% rated voltage.

Torsional analysis and testing:
 The generator set was tested to verify that the design is not subjected to harmful torsional stresses in excess of 5000 psi. A spectrum analysis of the transducer output was conducted over the speed range of 1200 to 2000 RPM.

Cooling system: 50 °C ambient
 0.50 in. H₂O restriction

The cooling system was tested to determine ambient temperature and static restriction capabilities. The test was performed at full rated load in elevated ambient temperature under static restriction conditions.

Durability:
 The generator set was subjected to a minimum 500 hour endurance test operating at variable load up to the Standby rating based upon MIL-STD-705 to verify structural soundness and durability of the design.

Electrical and mechanical strength:
 The generator set was tested to several single phase and three phase faults to verify that the generator can safely withstand the forces associated with short circuit conditions. The generator set was capable of producing full rated output at the conclusion of the testing.

Steady state performance:
 The generator set was tested to verify steady state operating performance was within the specified maximum limits.

Voltage regulation: ± 0.5%
 Random voltage variation: ± 0.3%
 Frequency regulation: Isochronous
 Random frequency variation: ± 0.25%

Transient performance:
 The generator set was tested with the standard alternator to verify single step loading capability as required by NFPA 110. Verify acceptable Voltage and frequency response on load addition or rejection were evaluated. The following results were recorded:

Full load acceptance:

Voltage dip:	30.1%
Recovery time:	3.6 seconds
Frequency dip:	9.9%
Recovery time:	3.8 seconds

Full load rejection:

Voltage rise:	12.8%
Recovery time:	3.8 seconds
Frequency rise:	3.2%
Recovery time:	1.5 seconds

Harmonic analysis:
 (per MIL-STD-705B, method 601.4)

<u>Harmonic</u>	<u>Line to Line</u>		<u>Line to Neutral</u>	
	<u>No load</u>	<u>Full load</u>	<u>No load</u>	<u>Full load</u>
3	0.1	0.1	0.1	0.1
5	0.3	1.2	0.3	1.1
7	0.4	1.1	0.4	1.0
9	0.0	0.0	0.0	0.0
11	0.7	0.9	0.6	0.8
13	0.2	0.3	0.1	0.2
15	0.0	0.0	0.0	0.0



Warranty Statement

Global Commercial Warranty Statement

Generator Set

Limited Warranty

Commercial Generating Set

This limited warranty applies to all Cummins Power Generation® branded commercial generating sets and associated accessories (hereinafter referred to as "Product").

This warranty covers any failures of the Product, under normal use and service, which result from a defect in material or factory workmanship.

Warranty Period:

The warranty start date[†] is the date of initial start up, first rental, demonstration or 18 months after factory ship date, whichever is sooner. See table for details.

Continuous Power (COP) is defined as being the maximum power which the generating set is capable of delivering continuously whilst supplying a constant electrical load when operated for an unlimited number of hours per year. No overload capability is available for this rating.

Prime Power (PRP) is defined as being the maximum power which a generating set is capable of delivering continuously whilst supplying a variable electrical load when operated for an unlimited number of hours per year. The permissible average power output over 24 hours of operation shall not exceed 70% of the PRP. For applications requiring permissible average output higher than stated, a COP rating should be used.

Limited-Time Running Power (LTP) is defined as the maximum power available, under the agreed operating conditions, for which the generating set is capable of delivering for up to 500 hours of operation per year.

Emergency Standby Power (ESP) is defined as the maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering in the event of a utility power outage or under test conditions for up to 500 hours of operation per year. The permissible average power output over 24 hours of operation shall not exceed 70% of the ESP.

Environmental Protection Agency – Stationary Emergency (EPA-SE) is defined as being the maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generator set is capable of delivering in the event of a utility power outage or under test conditions and used in strict accordance with the EPA NSPS for stationary engines, 40 CFR part 60, subparts IIII and JJJJ, where a reliable utility must be present. The permissible average power output over 24 hours of operation shall not exceed 70% of the EPA-SE.

Data Center Continuous (DCC) is defined as the maximum power which the generator is capable of delivering continuously to a constant or varying electrical load for unlimited hours in a data center application.

**Base Warranty Coverage Duration
(Whichever occurs first)**

Rating	Months	Max. Hours
COP	12	Unlimited
PRP	12	Unlimited
LTP	12	500 hrs
ESP	24	1000 hrs
EPA-SE	24	Unlimited
DCC	24	Unlimited

[†] Warranty start date for designated rental and oil and gas model Products is determined to be date of receipt of Product by the end customer.

Cummins Power Generation® Responsibilities:

In the event of a failure of the Product during the warranty period due to defects in material or workmanship, Cummins Power Generation® will only be responsible for the following costs:

- All parts and labor required to repair the Product.
- Reasonable travel expenses to and from the Product site location.
- Maintenance items that are contaminated or damaged by a warrantable failure.

Owner Responsibilities:

The owner will be responsible for the following:

- Notifying Cummins Power Generation® distributor or dealer within 30 days of the discovery of failure.
- Installing, operating, commissioning and maintaining the Product in accordance with Cummins Power Generation®'s published policies and guidelines.
- Providing evidence for date of commissioning.
- Providing sufficient access to and reasonable ability to remove the Product from the installation in the event of a warrantable failure.
- Incremental costs and expenses associated with Product removal and reinstallation resulting from non-standard installations.
- Costs associated with rental of generating sets used to replace the Product being repaired.
- Costs associated with labor overtime and premium shipping requested by the owner.
- All downtime expenses, fines, all applicable taxes, and other losses resulting from a warrantable failure.

Limitations:

This limited warranty does not cover Product failures resulting from:

- Inappropriate use relative to designated power rating.
- Inappropriate use relative to application guidelines.
- Inappropriate use of an EPA-SE application generator set relative to EPA's standards.
- Normal wear and tear.
- Improper and/or unauthorized installation.
- Negligence, accidents or misuse.
- Lack of maintenance or unauthorized repair.
- Noncompliance with any Cummins Power Generation® published guideline or policy.
- Use of improper or contaminated fuels, coolants or lubricants.
- Improper storage before and after commissioning.
- Owner's delay in making Product available after notification of potential Product problem.
- Replacement parts and accessories not authorized by Cummins Power Generation®.
- Use of Battle Short Mode.
- Owner or operator abuse or neglect such as: operation without adequate coolant or lubricants; overfueling; overspeeding; lack of maintenance to lubricating, cooling or air intake systems; late servicing and maintenance; improper storage, starting, warm-up, run-in or shutdown practices, or for progressive damage resulting from a defective shutdown or warning device.

- Damage to parts, fixtures, housings, attachments and accessory items that are not part of the generating set.

This limited warranty does not cover costs resulting from:

- Difficulty in gaining access to the Product.
- Damage to customer property.

A "Data center" is defined as a dedicated facility that house computers and associated equipment for data storage and data handling.

Reliable utility is defined as utility power without routine or regularly scheduled black-outs.

Please contact your local Cummins Power Generation® Distributor for clarification concerning these limitations.

CUMMINS POWER GENERATION® RIGHT TO FAILED COMPONENTS:

Failed components claimed under warranty remain the property of Cummins Power Generation®. Cummins Power Generation® has the right to reclaim any failed component that has been replaced under warranty.

Extended Warranty:

Cummins Power Generation® offers several levels of Extended Warranty Coverage. Please contact your local Cummins Power Generation® Distributor for details.

www.power.cummins.com

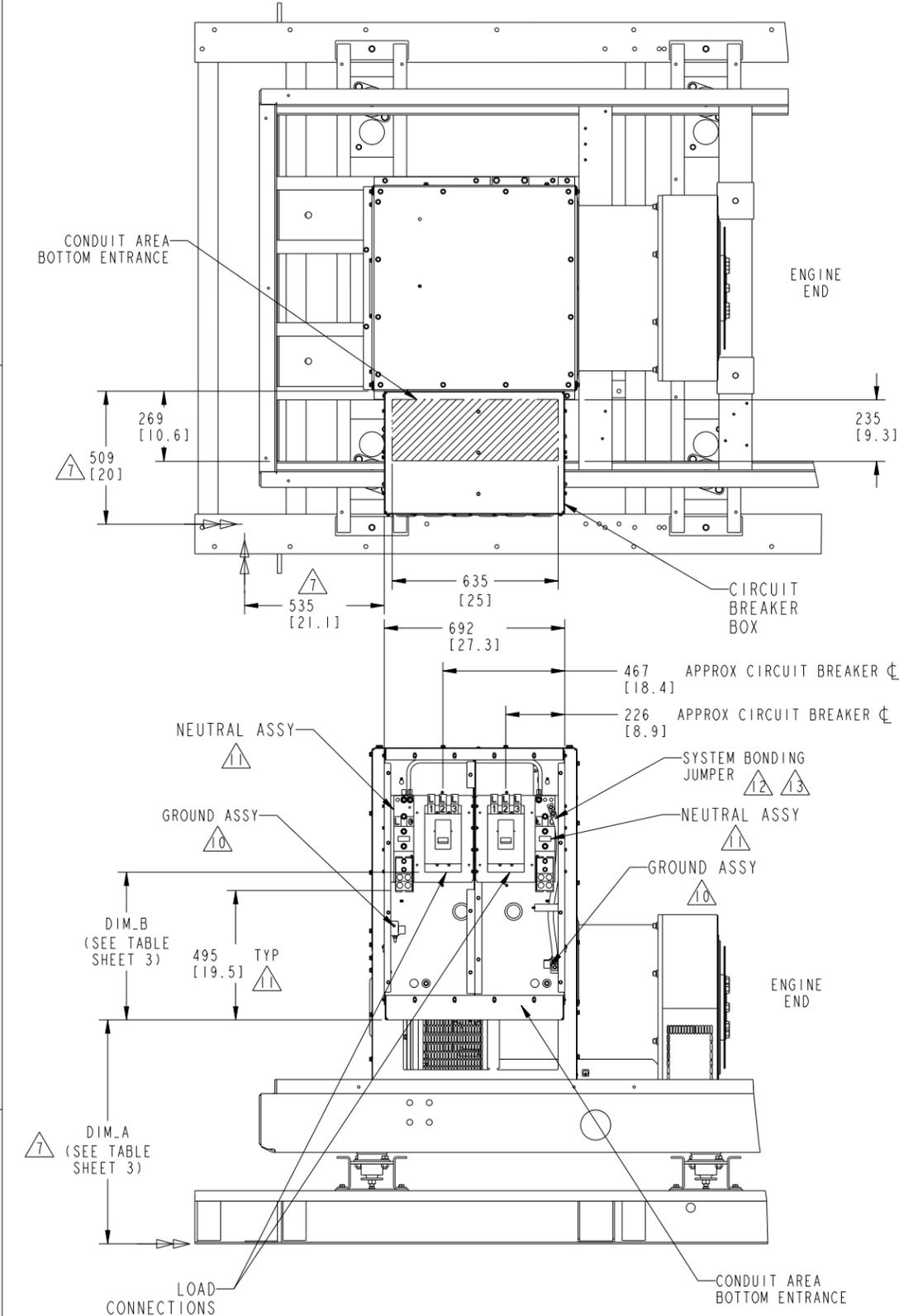
THE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS POWER GENERATION® IN REGARD TO THE PRODUCT. CUMMINS POWER GENERATION® MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

IN NO EVENT IS CUMMINS POWER GENERATION® LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

This limited warranty shall be enforced to the maximum extent permitted by applicable law. This limited warranty gives the owner specific rights that may vary from state to state or from jurisdiction to jurisdiction.

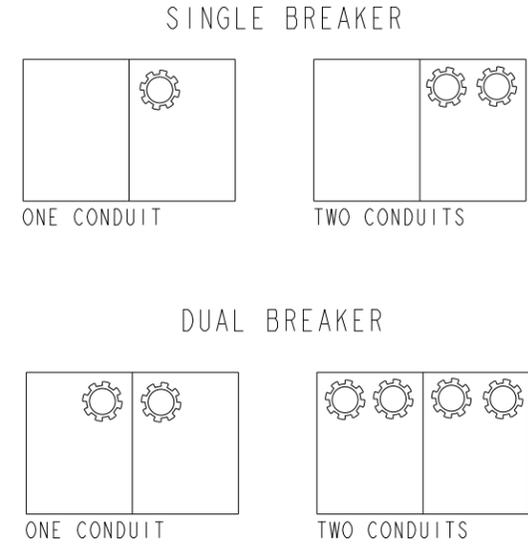
Product Model Number: _____
 Product Serial Number: _____
 Date in Service: _____

REL NO	LTR	NO	REVISION	DWN	CKD	APVD	DATE
ECO-180039	B	1	SEE SHEET 3	CJF	PA	L CASSENS	31AUG18
		2	SEE SHEET 3	CJF	PA	L CASSENS	31AUG18

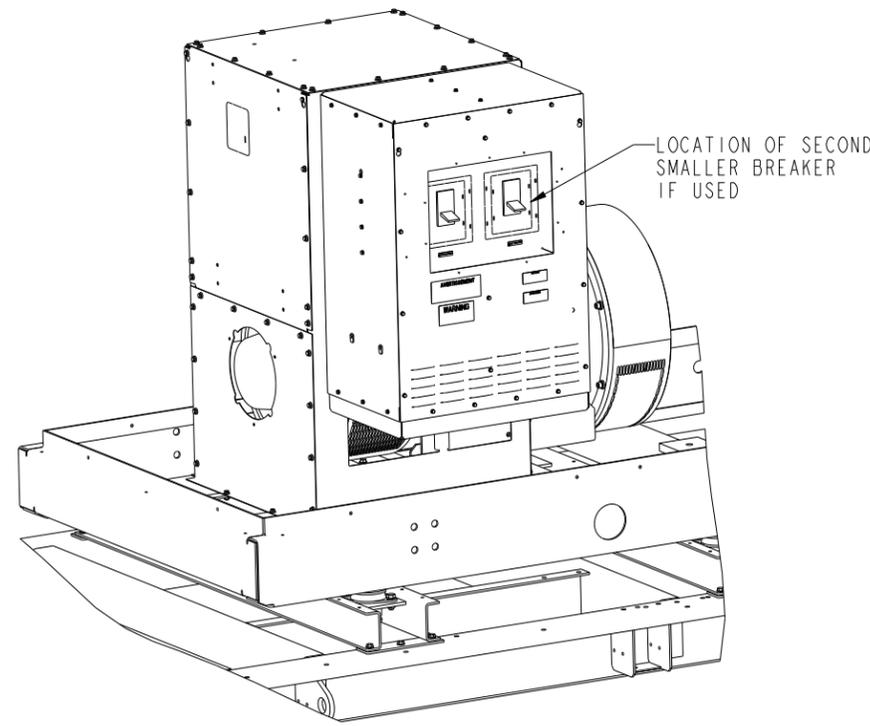


DFEJ/DFEK
CIRCUIT BREAKER BOX
(RIGHT HAND BOTTOM ENTRY CONFIGURATION
NSJ/NLG-FRAME BREAKERS SHOWN)

NSJ/NLG-FRAME 300-600A
RECOMMENDED CONDUIT LOCATIONS



BOTTOM COVER
(LOOKING DOWN AT BOTTOM
OF BREAKER BOX)



NOTES:

- 1 ALL DIMENSIONS ARE FOR REFERENCE ONLY
- 2 DIMENSIONS SHOWN IN [] ARE IN INCHES
- 3 BOTTOM COVER IS ADJUSTABLE VERTICALLY PLUS OR MINUS 6 [0.25] TO EASE CONDUIT ATTACHMENT
- 4 THESE WIRE-CONDUIT COMBINATIONS MEET NEC AND CEC. TO USE OTHER COMBINATIONS, REFER TO APPLICABLE CODES TO ENSURE THAT WIRE AMPACITY, BEND SPACE AND GUTTER SPACE MEET THE REQUIREMENTS
- 5 "NS" SHUNT TRIP HAS NO INTERNAL CONTACTS, IT MUST BE USED IN CONJUNCTION WITH AUXILIARY CONTACTS TO ACCEPT CONTINUOUS APPLIED VOLTAGE. IT CAN OPERATE AT 75% OF NOMINAL VOLTAGE
- 6 CONDUITS AND WIRING SHOULD BE DESIGNED AND INSTALLED TO ALLOW FOR NORMAL GENERATOR SET MOVEMENT DURING CRANKING SHUT DOWN OR EXPECTED SEISMIC DISTURBANCES
- 7 SEE FOUNDATION LAYOUT DRAWING (GENSET OUTLINE (FOUNDATION)) FOR THE LOCATION OF THE ELECTRICAL STUB UP AREAS AND FOUNDATION REFERENCE POINT ()
- 8 ON FLORIDA UNITS WITH TANKS (FEATURE CODE LI16) ADD 106 [4.2] FOR RISER BEAMS THAT ARE REQUIRED ON THE UNDERSIDE OF THE TANK
- 9 BOX DIMENSIONS AND CONDUIT LOCATIONS ARE THE SAME FOR ENTRANCE BOX WITHOUT CONDUITS
- 10 EQUIPMENT GROUND AND GROUNDING ELECTRODE LUG IS MECHANICAL TYPE, COPPER 400 MCM-6 AWG SCREW 11/16"-16 UN-2B 5/16" HEX WRENCH
RECOMMENDED TORQUES:
250 MCM-1 AWG - 375 IN-LBS
2-6 AWG - 275 IN-LBS
- 11 NEUTRAL LUG IS MECHANICAL TYPE, COPPER #2-600 MCM SCREW 15/16"-16 UN-2B 3/8" HEX WRENCH
RECOMMENDED TORQUES:
600 MCM-4 AWG - 500 IN-LBS
- 12 TORQUE TO 9.8-11.9 Nm [7.2-8.8 FT-LBS] HARDWARE IS PROVIDED WITH BONDING JUMPER.
- 13 250 MCM SYSTEM BONDING JUMPER SIZED PER NEC TABLE 250.122 USING COPPER CABLE FOR A MAXIMUM AMPACITY RATING OF 2000 AMPS.
- 14 CIRCUIT BREAKER LUGS - REFER TO RECOMMENDED TORQUE ON LABEL.
- 15 MINIMUM WIRE BENDING SPACE AT BREAKER TERMINALS CALCULATED PER NEC TABLE 312.6(B) USING 500 MCM CABLES (2 WIRES PER TERMINAL), MECHANICAL LUGS USED AS TERMINALS.

NUMBER OF CONDUCTORS PER PHASE CALCULATED PER TABLE 310.16 USING COPPER CABLES RATED AT 75° C ON A MAXIMUM AMBIENT TEMP OF 40° C.
- 16 MINIMUM WIRE BENDING SPACE AT GROUND TERMINALS CALCULATED PER NEC TABLE 312.6(A) USING [3/0-14] CABLES (1 WIRE PER TERMINAL), MECHANICAL LUGS USED AS TERMINALS.

UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETERS		SHW TO: A040J749	DWN: M_LEHR		CUMMINS POWER GENERATION	
DO NOT SCALE PRINT		CKD: J_BRODY	APVD: J_BRODY		OUTLINE, CIRCUIT BREAKER	
DATE 25MAY11		FIRST USED ON DFEJ,DFEK		SITE CODE	PGF	
ANG TOL: ± 1.0°		SCALE: 3/32	D		A052W389	SHEET 1 OF 3

APPENDIX 7. RADIATION MONITORING REPORT

Use the reference factor to calculate the Dose Equivalent in the Radiation Building.

Participant Name, Number	Account	Subaccount Name	Subaccount Code	Customer Reference	Begin wear date	End wear date	Total DDE	Total LDE	Total SDE	Total Neutron	Fast Neutron	Dose Assessment
AREA MONITOR 1,95987	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	M	M	M	M	M	Standard
AREA MONITOR 1,95987	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	48	48	46	30	30	Standard
LABORATORY AREA,96457	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	11	11	10	M	M	Standard
LABORATORY AREA,96457	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	5	5	6	M	M	Standard
NUCLEAR AREA GATE,96455	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	3	3	3	M	M	Standard
NUCLEAR AREA GATE,96455	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	M	M	M	M	M	Standard
NUCLEAR AREA LEFT,96453	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	2	2	2	M	M	Standard
NUCLEAR AREA LEFT,96453	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	1	1	1	M	M	Standard
NUCLEAR AREA RIGHT,96454	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	1	2	2	M	M	Standard
NUCLEAR AREA RIGHT,96454	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	41	42	44	30	30	Standard
NUCLEAR AREA ROOM,96456	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	3	3	2	M	M	Standard
NUCLEAR AREA ROOM,96456	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	M	M	2	M	M	Standard
RADIATION PIT 1,96451	729748	DM-GUY	GUY	DM	2022/04/01	2022/06/30	1	1	M	M	M	Standard
RADIATION PIT 1,96451	729748	DM-GUY	GUY	DM	2022/07/01	2022/09/30	3	3	2	M	M	Standard
PIT MONITOR WL, 96632	729748	WL-GY	GUY	WL	4/1/2022	6/30/2022	M	M	M	M	M	Standard
PUBLIC AREA WL, 96633	729748	WL-GY	GUY	WL	4/1/2022	6/30/2022	M	M	M	M	M	Standard
PIT MONITOR WL, 96632	729748	WL-GY	GUY	WL	7/1/2022	9/30/2022	M	M	M	M	M	Standard
PUBLIC AREA WL, 96633	729748	WL-GY	GUY	WL	7/1/2022	9/30/2022	M	M	M	M	M	Standard

Radioactive emission results in our area monitors, installed within the radiation building, show the cumulative dose inside of radiation area was at **48 mrem** from **07/01/2022 to 09/30/2022 (91 days)** that is equal to **0.021 mrem/hr**. This dose is below the international standard levels for a controlled area which is **≤7.5μSv (0.75mrem) per hour**. M=No readings obtained

Source Storage and Calibration Building
Schlumberger Guyana Inc.

APPENDIX 7. RADIATION MONITORING REPORT

3RD. PARTY REPORT.



IMEX Incorporated
Industrial & Engineering Department
151 Karabiru Street Section C Enterprise, ECD, Guyana
Tel: 592-270-4477 • Email: info@imexlogic.com • www.imexlogic.com

For the account of: Schlumberger Guyana Inc.
Lot 1 Area X Houston
East Bank Demerara, Guyana

Certificate No.: IND/51308465/069/01 (1.1)
Date Issued: January 29, 2023
Testing Date(s): 14/Jul/2022

Monitoring Site: Lot 1 Area X, Houston **Site Description:** Perimeter fence and radiation source calibration building
Engineer/Technician: Eliyah Yehudah

Certificate of Radiation Monitoring

Point Description	Reading 1 ($\mu\text{Sv/h}$)	Reading 2 ($\mu\text{Sv/h}$)
Radiation Source Calibration Building – various monitoring points about the source storage pits (refer to enclosed report).		
Site 01	0.090	0.130
Site 02	0.140	0.090
Site 03	0.180	0.110
Site 04	0.080	0.120
Site 05	0.170	0.380
Site 06	0.110	0.080
Site 07	0.100	0.120
Site 08	0.080	0.100
Perimeter Fence Monitoring Points – various points about the perimeter fence line and main access road (refer to enclosed report).		
Site 09	0.090	
Site 10	0.080	
Site 11	0.070	
Site 12	0.150	
Site 13	0.090	
Site 14	0.130	
Site 15	0.140	
Site 16	0.080	
Site 17	0.130	
Site 18	0.090	
Site 19	0.110	
Site 20	0.090	
Site 21	0.120	
Site 22	0.130	
Site 23	0.080	
Site 24	0.120	
Site 25	0.130	
Site 26	0.090	
Site 27	0.080	
Site 28	0.080	

This report relates only to inspection conducted at the specified dates, times and locations. This report shall not be reproduced in part or full without the written approval of IMEX Inc.



IMEX Incorporated
Industrial & Engineering Department
151 Karabiru Street Section C Enterprise, ECD, Guyana
Tel: 592-270-4477 • Email: info@imexlogic.com • www.imexlogic.com

For the account of: Schlumberger Guyana Inc.
Lot 1 Area X Houston
East Bank Demerara, Guyana

Certificate No.: IND/51308465/069/01 (1.1)
Date Issued: January 29, 2022
Testing Date(s): 14/Jul/2022

Monitoring Site: Lot 1 Area X, Houston **Site Description:** Perimeter fence and radiation source calibration building
Engineer/Technician: Elijah Yehudah

Point Description	Reading 1 ($\mu\text{Sv/h}$)	Reading 2 ($\mu\text{Sv/h}$)
Site 29	0.100	
Site 30	0.080	
Site 31	0.100	
Site 32	0.090	

Remarks: Refer to the enclosed reference report number IND/51308465/069 for monitoring location details.

Elijah Yehudah

Engineer/Technician Signature:

Date:

Shelisha Gray

Quality Assurance Officer Signature:

Date:



This report relates only to inspection conducted at the specified dates, times and locations. This report shall not be reproduced in part or full without the written approval of IMEX Inc.



Technical Report

Title: Radiation Monitoring – Schlumberger Guyana Inc.

Report No.: IND/51308465/069

Prepared for: Schlumberger Guyana Inc.

Date: January 30, 2022

Prepared By: IMEX Incorporated – 151 Karabiru Street, Section C Enterprise,
ECD, Guyana

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Mission Statement.....	4
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Sampling Techniques & Methods	5
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Report No.: IND/51308465/069

Schlumberger Guyana Inc.
Lot 1 Area X Houston
East Bank Demerara, Guyana

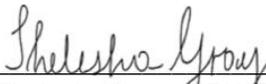
Subject: Radiation Monitoring
Schlumberger Guyana Inc. – Lot 1 Area X Houston

Dear Sir/Madam:

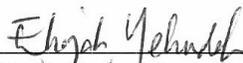
IMEX Inc. conducted radiation monitoring at the Schlumberger Guyana Inc. – Lot 1 Area x Houston on July 14, 2022. The survey was performed in response to the Client's request for services. The enclosed report represents our methodology, observations, reference standards, recommendations, and findings.

Thank you for your confidence in our Company. We appreciate the opportunity to work with you on this project.

Yours sincerely,



Thelesha Gray, MPH,BSN
Chief Operations Officer



Elijah Yehudah
Electrical Engineer



Executive Summary

Introduction

IMEX is an environmental and industrial service provider to companies in the oil and gas, manufacturing, hospitality, and mining industries. We provide laboratory testing, environmental monitoring, consulting, project management and procurement expertise to our customers.

Our laboratory is certified to the GYS170:2009 Laboratory Quality Standard and our company is a registered consulting firm with the Guyana Environmental Protection Agency.

Mission Statement

Our mission is "Connecting people to essential resources."

Scope of Work

IMEX Inc. was retained by Schlumberger Guyana Inc. to conduct radiation monitoring across the Company's work sites located at Lot 1 Area X Houston East Bank Demerara, Guyana (6.786391, -58.170917). Testing was conducted on July 14, 2022 at the locations outlined in the **Sample Points** section of this report.

Sample Points

Indoor – Radiation Source Calibration Building
Ambient – Perimeter Fence & Main Access Road

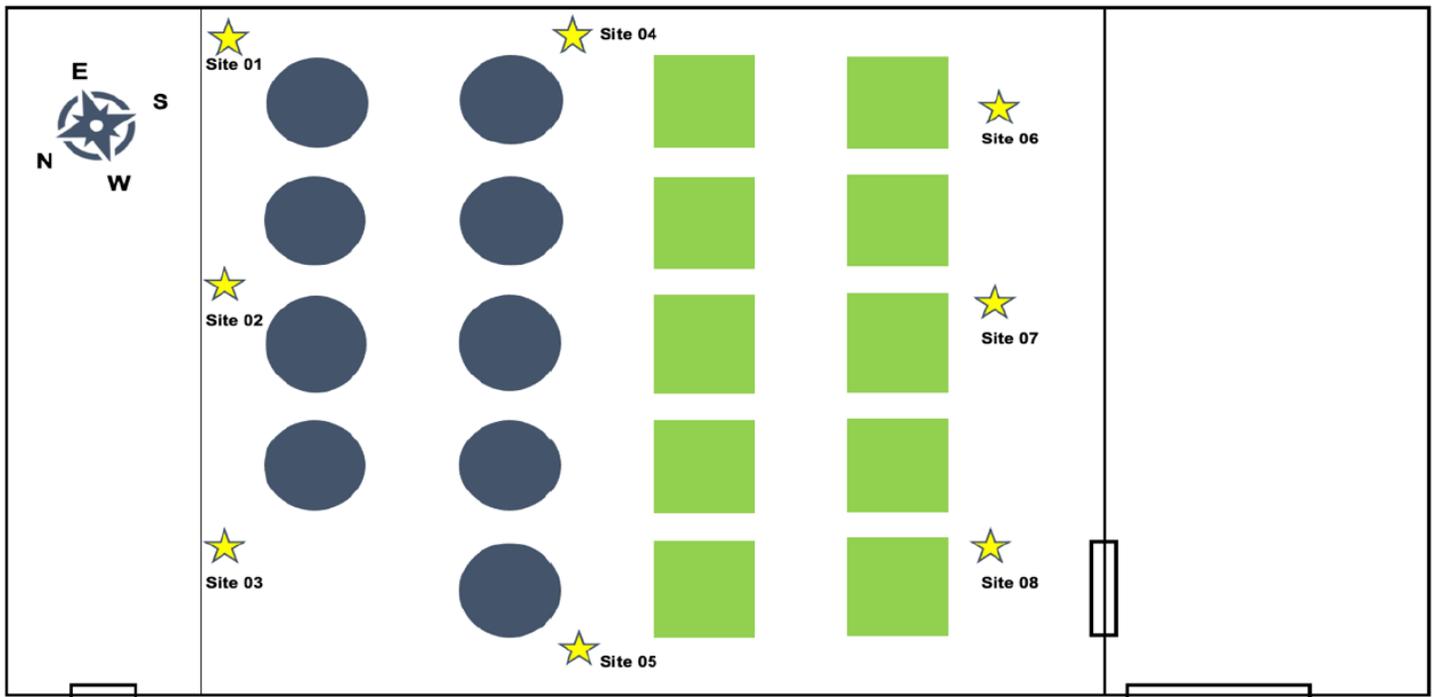


Figure 1: Indoor Monitoring Points - Radiation Source Calibration Building

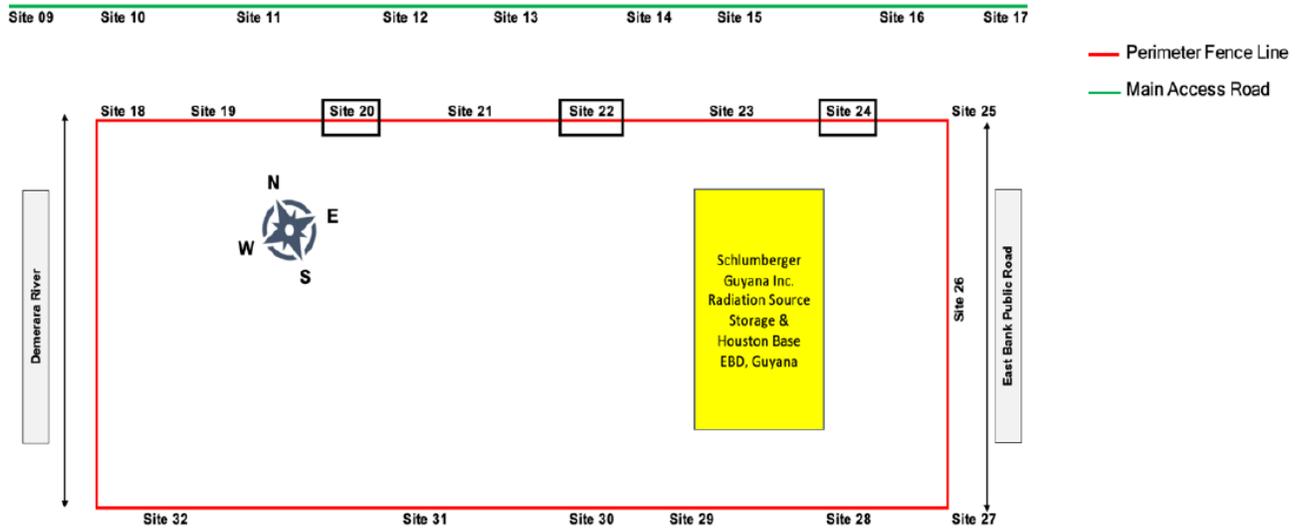


Figure 2: Ambient Monitoring - Perimeter Fence Line & Main Access Road

Sampling Techniques & Methods

A portable radiation meter was used to conduct the radiation survey at the various monitoring points noted in figures 1 and 2. A total of eight (8) indoor points and 24 ambient / background points were measured. Measurements were taken by steadily passing the meter in the area being monitored for 15-30 seconds. Once measurements stabilized, readings were recorded for each location in $\mu\text{Sv/h}$.

- Instrument Model: Radiation Alert – Ranger
- Serial Number: R314093
- Operating Range - 0.01 to 1000
- Energy Sensitivity - 3340 CPM/mR/hr referenced to Cs137
- Accuracy - $\pm 10\%$ with NIST Source Calibration referenced to Cs137

Summary Discussion of Results

Radiation naturally occurs at background levels in the environment. This background radiation is a result of cosmic activities in outer space and naturally occurring radioactive materials found on earth. Electronic devices and medical procedures such as cell phones, and X-rays is also a source of radiation. The health effects of radiation exposure take into consideration the type of exposure (external vs. internal), the strength of the dose received, susceptibility of the receptor, duration of exposure and the type of radiation. General public exposure to extremely high doses of radiation is rare. Threshold effects for radiation are established to identify the overt effects of high doses of radiation. However, non-threshold effects assume that any dose radiation can increase a receptor's risk for adverse effects. These include mainly genetic and fetal effects.

Radioactive emission testing was conducted at 24 test points about the Project's fence line and main access road.

The typical global background level for radioactive emissions is approximately 2.4 mSv/year or 2,400 $\mu\text{Sv/year}$. Permit 20210714-XRFS requires radiation emission not to exceed 25 $\mu\text{Sv/hour}$ or 1mSv/year (1000 $\mu\text{Sv/year}$). Average radiation readings from the perimeter fence line and access road locations

were noted to be 0.102 $\mu\text{Sv/h}$. When calculated over 365 days, the cumulative radiation dose is 876 $\mu\text{Sv/year}$. This dose is below both the average global background levels and permit requirements for radiation. The average indoor radiation was calculated at 0.120 $\mu\text{Sv/h}$. When the average background radiation measured from the perimeter fence line and main access road is subtracted from the average indoor radiation, net radiation from indoor equals 0.018 $\mu\text{Sv/h}$ or 157 $\mu\text{Sv/year}$.

Table 1: Radiation Monitoring Details for Lot 1 Area X

Point Description	Reading 1 ($\mu\text{Sv/h}$)	Reading 2 ($\mu\text{Sv/h}$)
Radiation Source Calibration Building – various monitoring points about the source storage pits (See figure 1).		
Site 01	0.090	0.130
Site 02	0.140	0.090
Site 03	0.180	0.110
Site 04	0.080	0.120
Site 05	0.170	0.380
Site 06	0.110	0.080
Site 07	0.100	0.120
Site 08	0.080	0.100
Perimeter Fence Monitoring Points – various points about the perimeter fence line and main access road (see figure 2).		
Site 09	0.090	
Site 10	0.080	
Site 11	0.070	
Site 12	0.150	
Site 13	0.090	
Site 14	0.130	
Site 15	0.140	
Site 16	0.080	
Site 17	0.130	
Site 18	0.090	
Site 19	0.110	
Site 20	0.090	
Site 21	0.120	
Site 22	0.130	
Site 23	0.080	
Site 24	0.120	
Site 25	0.130	
Site 26	0.090	
Site 27	0.080	
Site 28	0.080	
Site 29	0.100	
Site 30	0.080	
Site 31	0.100	
Site 32	0.090	

Appendix A – Calibration Certificate

CERTIFICATE OF CALIBRATION



S.E. INTERNATIONAL, INC.
 436 Farm Road P.O. Box 39 Summertown, TN. 38483
 Ph: 931.964.3561 Fax: 931.964.3564
 www.seintl.com | radiationinfo@seintl.com

Certificate Number:
22-216
CAL DATE: 1/30/2022
CAL DUE DATE: 1/30/2023

Ranger SN# R314093

Instrument Information:

Instrument: Radiation Alert
Type: GM Alarming Rate Meter
Model: Ranger
Serial: R314093
Make: LND
Tube Model: 7317
Detector: Internal
Input Sens: 2.4VDC
Inst Voltage set: 316VDC

Contamination Check:
Alarm Check:
Audio Check:
Received: Out of Spec:
Mechanical Check:
Battery Check: 3.19VDC
Tolerance: ± 10% ± 20% Out of Spec

Calibration Data:

S.E. International, Inc. Certifies the above described instrument was calibrated in a known radiation field using a Cs137 (662keV) beam calibrator. Transfer instrument MDH Industries, Model 2025 X-Ray Monitor, S.N. 4351, with 180cc Probe, S.N. 7773. Calibration is traceable to NIST DGB640/B7. GM detectors are positioned perpendicular to source. This calibration conforms to ANSI/ANSI Z540-1, ANSI N323-1978, ISO 17025. The results are tabulated below. Measurement of uncertainty is ± 5%. This certificate may not be reproduced, unless in full, without written approval from S.E. International, Inc. **TENNESSEE LICENSE# R-51002-C27**

Precision/Constancy Check performed with Cs¹³⁷ Source s/n 010818 | Precision: ± 10% ± 20%

Constancy Check: 1 uCi of Cs¹³⁷ indicates 0.352 mR/hr

Reading 1:	0.363 mR/hr	Temperature:	19.5 °C
Reading 2:	0.359 mR/hr	Relative Humidity:	41.9%
Reading 3:	0.334 mR/hr	mmHg:	739.0
Mean:	0.352 mR/hr		

Notes:
 Dead Time is set at 1.000E-04 Gamma Sensitivity is set at 3666 For more on the Dead Time and Gamma Sensitivity, see owners manual. Unit: "NEW"

Decade Range	Reference Point	Instrument Meter Reading after Calibration *	Correction Factors for > +/- 10%
10 mR/hr - 100 mR/hr	50mR/hr	50.01mR/hr	None
1 mR/hr - 10 mR/hr	5mR/hr	4.785mR/hr	None
0.1 mR/hr - 1 mR/hr	0.5mR/hr	0.477mR/hr	None

** = Range calibrated to electronic standard | * indicates 1 minute average

Cs137 Gamma 6810 Capsule S/N A-855 and Model 28-5A Calibrator S/N 10291 calibrated monthly for decay
 Multimeter S/N 86820561 Cal Date: 19 Nov. 2021 Cal Due: 22 Nov. 2022
 Arb Gen. S/N US34004570 Cal Date: DY MO YEAR Cal Due: N/A

Calibrated by: *Floyd Hagler*
 Floyd Hagler

References

1. “Department of Health,” Radiation and Health, accessed August 20, 2022. <https://www.health.ny.gov/publicatins/4402/>
2. “Radiation Health Effects,” EPA (Environmental Protection Agency), accessed August 20, 2022. <https://www.epa.gov/radiation/radiation-health-effects#:~:text=Exposure%20to%20very%20high%20levels,as%20cancer%20and%20cardiovascular%20disease.>
3. “Radiation.” Accessed August 1, 2022. https://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Nuclear_Information/pocket_guide_radiation.pdf.

Disclaimer

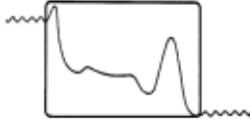
This is IMEX Incorporated's report of a walk-through, visual survey and an on-site measurement of the parameters described in this report. The test results only apply to those rooms or spaces that were tested and that are specifically described during this survey.

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Government and industry guidelines, vendor product specifications and other information gathered from other sources are always evolving. The included information has been provided for informational purposes, at the best effort of IMEX Incorporated to be up to date. However, IMEX Incorporated takes no responsibility for errors or omissions in the text provided about government and Industry guidelines, vendor product specifications or other information gathered from other sources and included in this document.

APPENDIX 8. EXAMPLE OF LEAK TEST CERTIFICATE.

	Monitoring Services P.O. BOX 268677 . HOUSTON, TEXAS 77207-8677 . AREA CODE 713-478-8820 . FAX 281-532-0509 leaktest1@ccmcast.net
SEALED SOURCE LEAK TEST CERTIFICATE	
CarolAnn Nangoo SCHLUMBERGER TT93/ATRL 2-1/4 MM SOUTH TRUNK ROAD LA ROMAIN TRINIDAD W.I.	CUSTOMER #: <u>2757</u> SOURCE #: <u>43934</u> ACCOUNT #: <u>ATRL</u>
RADIONUCLEIDE: <u>AM241BE</u>	SOURCE CODE: <u>NSRT</u>
ACTIVITY: <u>7.5</u> <u>CI</u>	SERIAL NO: <u>Q1197</u>
WIPE DATE <u>5/21/2022</u>	
EFFICIENCY: <u>1.32</u>	
GROSS CPM: <u>25</u> BKG CPM: <u>18</u> NET CPM: <u>7</u>	
NET CPM EFF X 2.22x10 ⁶ DPM/u CI = MICROCURIE	
THE ABOVE SOURCE WIPE TEST HAS BEEN ASSAYED IN ACCORDANCE WITH OUR RADIOACTIVE MATERIAL LICENSE AND THE APPROPRIATE REGULATORY REQUIREMENTS. THE REGULATIONS DEFINE A LEAKING SOURCE AS ONE FROM WHICH AN APPROPRIATE WIPE TEST HAS REMOVED 0.005 (5.0X10E-3) MICROCURIE OR MORE OF ACTIVITY.	
THE REMOVABLE ACTIVITY WAS: <u>2.39E-06</u> MICROCURIE <u>8.84E-02</u> Bq	
ASSAY NO.: <u>7/11/2022 99</u>	DATE: <u>7/12/2022</u>
ASSAYED BY: 	

Source Storage and Calibration Building
Schlumberger Guyana Inc.

**APPENDIX 9. THE SCHLUMBERGER HAZARDOUS MATERIALS SHIPPING PAPER
(HAZMAT FORM)**

HAZARDOUS MATERIAL SHIPPING PAPER - WIRELINE

STC-4230-AB (09/2019)

SERVICE ORDER NO.	DISTRICT	TRUCK NO.	LOCATION CODE
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SHIPPING NAME: UN3332, RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, 7						SHIPMENT BY WATER <input type="checkbox"/> YES <input type="checkbox"/> NO	INTERNAL COMPANY INFORMATION		
RADIONUCLIDE	ACTIVITY	LABEL	TI	QTY.	SERIAL NO.	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	PROJECT CODE	USAGE
CALIFORNIUM 252	0.7 GBq ea. (19 mCi ea.)	RADIOACTIVE YELLOW III	9.0			TRANSPORTATION SHIELD	63 (139 lbs.)	NNLS-EWA	NEUTRON SOURCE LOGGING

SHIPPING NAME: UN3332, RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, 7, RQ									
RADIONUCLIDE	ACTIVITY	LABEL	TI	QTY.	SERIAL NO.	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	PROJECT CODE	USAGE
CESIUM 137	63 GBq ea. (1.7 Ci ea.)	RADIOACTIVE YELLOW III	0.7			TRANSPORTATION SHIELD	33 (73 lbs.)	GSR-JZ GGLS-EZ/FZ	DENSITY SOURCE LOGGING
AMERICIUM 241 BERYLLIUM	18.5 GBq ea. (0.5 Ci ea.)	RADIOACTIVE YELLOW III	0.9			TRANSPORTATION SHIELD	30 (66 lbs.)	NSR-GB	CNB-AB
AMERICIUM 241 BERYLLIUM	370 GBq ea. (10 Ci ea.)	RADIOACTIVE YELLOW III	5.2			TRANSPORTATION SHIELD	63 (139 lbs.)	NSR-M	NDT/CNT-E SOURCE
AMERICIUM 241 BERYLLIUM	592 GBq ea. (16 Ci ea.)	RADIOACTIVE YELLOW III	6.7			TRANSPORTATION SHIELD	63 (139 lbs.)	NSR-F/L/LB NNLS-AFC/R	NEUTRON SOURCE LOGGING
AMERICIUM 241 BERYLLIUM	296 GBq ea. (8 Ci ea.)	RADIOACTIVE YELLOW III	3.4			TRANSPORTATION SHIELD	63 (139 lbs.)	NSR-LC/LX NNLS-C/D	NEUTRON SOURCE LOGGING

SHIPPING NAME: UN2911, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - INSTRUMENTS OR ARTICLES, 7									
RADIONUCLIDE	FORM	ACTIVITY	LABEL	QTY.	SERIAL NO.	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	PROJECT CODE	USAGE
AMERICIUM 241-LTD. QTY.	SOLID	_____ kBq ea. (_____ µCi ea.)	UN2911			STEEL TUBE		ASR-A ASR-B	NGT/MTT
COBALT 60 LTD. QTY.	SOLID	_____ kBq ea. (_____ µCi ea.)	UN2911	QTY. ISSUED	QTY. RETURNED	STEEL TUBE		PIP TAG IN INSTRUMENT OR ARTICLE	DEPTH CONTROL

Notes: Activity: ASR = 1.85 MBq (50 µCi) ea.; ASR-B = 100 kBq (2.7µCi) ea. PIP Tag = 37 kBq per PIP tag, 5 PIP Tag per strip. Weight ASR-A 20 kg (44 lb); ASR-B = 50 kg (121 lb) ea.

SHIPPING NAME: UN2909, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES MANUFACTURED FROM NATURAL THORIUM									
RADIONUCLIDE	FORM	ACTIVITY	LABEL	QTY.	SERIAL NO.	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	PROJECT CODE	USAGE
THORIUM NATURAL LTD. QTY.	SOLID	55 kBq ea. (1.5 µCi ea.)	UN2909			FABRIC COVER	0.5 (1 Lb.)	GSR-U/Y	CALIB. BLANKET

SHIPPING NAME: UN2910, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - LIMITED QUANTITY OF MATERIAL, 7									
RADIONUCLIDE	FORM	ACTIVITY	LABEL	QTY. ISSUED	QTY. RETURNED	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	PROJECT CODE	USAGE
COBALT 60 LTD. QTY.	SOLID	_____ kBq ea. (_____ µCi ea.)	UN2910			TRANSPORTATION BOX OR SHIELD			DEPTH CONTROL

Note: 37 kBq per PIP Tag with 5 PIP Tags per strip

SHIPPING NAME: UN1080, SULPHUR HEXAFLUORIDE, 2,2, DOT-SP 10511									
SHIPPING DESCRIPTION	LABEL	QTY.	PNG SERIAL NO(S).	TOOL HOUSING SERIAL NO(S).	PACKAGE TYPE	GROSS PKG. WT. IN KILOGRAMS	TOOL CODE		
_____ g of SF6 (SULPHUR HEXAFLUORIDE)	2.2 + UN2911				STEEL TUBE		PNG- (A/B/G/H/K)		

Note: Item above is also UN2911, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE (Qty. 55.5 GBq Tritium)
 Add SF6 contents above: PNG-A/K = 10g; PNG-B = 14g; PNG-G = 54g; PNG-H = 30g

SHIPPING NAME	BATTERY TYPE	QTY. LITHIUM (grams)	NUMBER of BATTERIES	LABEL	PACKAGE TYPE
UN3091, LITHIUM METAL BATTERY CONTAINED IN EQUIPMENT, 9				CLASS 9	STEEL TUBE
UN3090, LITHIUM METAL BATTERY, 9				CLASS 9	TRANSPORT CASE

Note: Lithium Contents per battery: TBSB-B = 61.2g; TBSB-C = 106g; DPN = 96.4g; BMC/DEB = 3.25g

SURVEYS AND CHECKS TO BE PERFORMED IN ACCORDANCE WITH THE FIELD RADIATION PROCEDURES

OUT OF PIT SURVEY METER		SURVEY METERS RECORD JOB SURVEY METER				INTO PIT SURVEY METER	
SURVEY METER MODEL & NUMBER	DATE OF LAST CALIBRATION	SURVEY METER MODEL & NUMBER	DATE OF LAST CALIBRATION	SURVEY METER MODEL & NUMBER	DATE OF LAST CALIBRATION		
BACKGROUND RADIATION MEASUREMENT AT WELLSITE (BY QUALIFIED JOB SUPERVISOR):		TIME OF SURVEY	DATE OF SURVEY	METER READING	CHOOSE UNITS: mrem/hr µSv/hr	PRINT NAME	SIGNATURE

WELLSITE ARRIVAL CHECK BY QUALIFIED JOB SUPERVISOR I HAVE PERSONALLY CHECKED THAT EACH SOURCE SHIELD AND THE GR JIG LISTED IN THIS HAZMAT IS CORRECTLY LOCATED AND SECURED INSIDE THE LOGGING TRUCK COMPARTMENT OR OVERPACK	WELLSITE DEPARTURE CHECK BY QUALIFIED JOB SUPERVISOR I HAVE PERSONALLY CHECKED THAT EACH SOURCE SHIELD IS TIED DOWN WITH CHAIN AND LOCKED TO THE TIE-POINT INSIDE THE LOGGING TRUCK COMPARTMENT OR OVERPACK, THE GR JIG SECURED AND THE LOGGING TRUCK COMPARTMENT OR OVERPACK IS LOCKED		
TIME OF CHECK	PRINT NAME	TIME OF CHECK	PRINT NAME
DATE OF CHECK	SIGNATURE	DATE OF CHECK	SIGNATURE

Survey 1 – OUT OF PIT – BY ANY QUALIFIED EMPLOYEE / HAZMAT NO. R -

I HAVE PERSONALLY CHECKED EACH LOGGING SOURCE SHIELD WITH A SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN. WHEN APPLICABLE, I HAVE ALSO VERIFIED THE PRESENCE OF EACH GAMMA RAY BLANKET AND/OR PIP TAG.

SOURCE S/N	TIME OF SURVEY	DATE OF SURVEY
SOURCE S/N	PRINT NAME	
SOURCE S/N	SIGNATURE	

Survey 4 - POST JOB - BY QUALIFIED JOB SUPERVISOR

I HAVE PERSONALLY CHECKED EACH LOGGING SOURCE SHIELD WITH A SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN. WHEN APPLICABLE, I HAVE ALSO VERIFIED THE PRESENCE OF EACH GAMMA RAY BLANKET AND/OR PIP TAG.

SOURCE S/N	TIME OF SURVEY	DATE OF SURVEY
SOURCE S/N	PRINT NAME	
SOURCE S/N	SIGNATURE	

Survey 2 - BEFORE LOGGING TOOLS - BY QUALIFIED JOB SUPERVISOR

TOOL CODE	METER READING	CHOOSE UNITS: mrem/hr µSv/hr	TIME/DATE OF SURVEY	PRINT NAME/SIGNATURE

Survey 5 - WELLSITE DEPARTURE - BY QUALIFIED OPERATOR

I HAVE PERSONALLY CHECKED EACH LOGGING SOURCE SHIELD WITH A SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN. WHEN APPLICABLE, I HAVE ALSO VERIFIED THE PRESENCE OF EACH GAMMA RAY BLANKET AND/OR PIP TAG.

SOURCE S/N	TIME OF SURVEY	DATE OF SURVEY
SOURCE S/N	PRINT NAME	
SOURCE S/N	SIGNATURE	

Survey 3 - AFTER LOGGING TOOLS - BY QUALIFIED JOB SUPERVISOR

TOOL CODE	METER READING	CHOOSE UNITS: mrem/hr µSv/hr	TIME/DATE OF SURVEY	PRINT NAME/SIGNATURE

Survey 6 – INTO PIT – BY ANY QUALIFIED EMPLOYEE / HAZMAT NO. R -

I HAVE PERSONALLY CHECKED EACH LOGGING SOURCE SHIELD WITH A SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN. WHEN APPLICABLE, I HAVE ALSO VERIFIED THE PRESENCE OF EACH GAMMA RAY BLANKET AND/OR PIP TAG.

SOURCE S/N	TIME OF SURVEY	DATE OF SURVEY
SOURCE S/N	PRINT NAME	
SOURCE S/N	SIGNATURE	

A COMPLETED COPY MUST BE RETAINED IN DISTRICT FILE FOR 5 YEARS

THIS IS TO CERTIFY THAT THE ABOVE-NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION. THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR CARGO-ONLY AIRCRAFT

DESTINATION / HAZMAT NO.	DATE	PRINT NAME	SIGNATURE
DESTINATION / HAZMAT NO.	DATE	PRINT NAME	SIGNATURE



**EMERGENCY
TELEPHONE NO.
281-595-3518**

**US DOT HAZARDOUS MATERIALS CERTIFICATE
OF REGISTRATION NO. _____
(OR COPY OF CERTIFICATE)**

Page _____ of _____
No. R-

HAZARDOUS MATERIAL SHIPPING PAPER - D&M RADIOACTIVE MATERIALS
STC-4064-D-USA (11/13)

S.O. / JOB NO.	DISTRICT	UNIT NO.	LOCATION CODE
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SHIPPING NAME: UN3332, RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, 7, RQ

RADIONUCLIDE	ACTIVITY	LABEL	TRANSPORT INDEX	QTY.	SERIAL NO.	PACKAGE TYPE	GROSS WT. IN KILOGRAMS	PROJECT CODE	USAGE
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE YELLOW III	8.5			NGCS-AB SHIELD #	405 (890 lb)	GSR-Z	RNGA-B DUAL SOURCE ASSEMBLY
AMERICIUM 241	278 GBq (7.5 Ci)			NSR-T					
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE YELLOW III	8.5			NGCS-AB # IN OVERPACK #		GSR-Z	
AMERICIUM 241	278 GBq (7.5 Ci)			NSR-T					
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE YELLOW III	5.5			NGCS-BA SHIELD #	576 (1267 lb)	GSR-Z	RNGA-C DUAL SOURCE ASSEMBLY
AMERICIUM 241	370 GBq (10 Ci) 444 GBq (12 Ci) 555 GBq (15 Ci)			NSR-M					
CESIUM 137	63 GBq (1.7 Ci)			RADIOACTIVE YELLOW III	5.5				
AMERICIUM 241	370 GBq (10 Ci) 444 GBq (12 Ci) 555 GBq (15 Ci)	NSR-M							
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE YELLOW III	5.5			NGCS-CB SHIELD #	630 (1386 lb)	GSR-Z	RNGA-D DUAL SOURCE ASSEMBLY
AMERICIUM 241	370 GBq (10 Ci)			NSR-U					
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE YELLOW III	5.5			NGCS-CB # IN OVERPACK #		GSR-J/Z	
AMERICIUM 241	370 GBq (10 Ci)			NSR-U					
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE WHITE I	N/A			DVGTS SHIELD #	543 (1197 lb)	GGLS	DENSITY SOURCE FOR ECOSCOPE
CESIUM 137	63 GBq (1.7 Ci)	RADIOACTIVE WHITE I	N/A			DVGTS SHIELD # IN OVERPACK #		GGLS	

**SHIPPING NAME: UN2909, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES
MANUFACTURED FROM NATURAL THORIUM, 7**

RADIONUCLIDE	FORM	ACTIVITY	LABEL	QTY.	SERIAL NO.	PROGRAM TYPE	GROSS WT. IN KILOGRAMS	PROJECT CODE	USAGE
THORIUM NATURAL LTD. QTY.	SOLID	111 kBq (0.003 mCi)	UN 2909			FABRIC COVER	0.5 (1 lb)	GSR-D	CALIBRATION BLANKET

The following surveys must be performed for movement of sources TO and FROM the Wellsite/Rig
These surveys are a regulatory requirement and shall be performed by an authorized and competent employee.
All survey meters utilized shall have valid calibration and be functioning correctly

OUT OF FACILITY STORAGE			
I HAVE PERSONALLY CHECKED EACH LISTED LOGGING SOURCE SHIELD WITH THE LISTED SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN			
METER MODEL		METER S / N	
SURVEY DATE		CALIBRATION DATE	
SURVEY TIME		BACKGROUND READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
PRINT NAME	SIGNATURE		

INTO RIG TEMPORARY STORAGE			
I HAVE PERSONALLY CHECKED EACH LISTED LOGGING SOURCE SHIELD WITH THE LISTED SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN			
METER MODEL		METER S / N	
SURVEY DATE		CALIBRATION DATE	
SURVEY TIME		BACKGROUND READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
PRINT NAME	SIGNATURE		

OUT OF RIG TEMPORARY STORAGE			
I HAVE PERSONALLY CHECKED EACH LISTED LOGGING SOURCE SHIELD WITH THE LISTED SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN			
METER MODEL		METER S / N	
SURVEY DATE		CALIBRATION DATE	
SURVEY TIME		BACKGROUND READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
PRINT NAME	SIGNATURE		

INTO FACILITY STORAGE			
I HAVE PERSONALLY CHECKED EACH LISTED LOGGING SOURCE SHIELD WITH THE LISTED SURVEY METER TO ENSURE THAT THE SOURCE IS CONTAINED WITHIN			
METER MODEL		METER S / N	
SURVEY DATE		CALIBRATION DATE	
SURVEY TIME		BACKGROUND READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
SOURCE CODE + S/N		METER READING	
PRINT NAME	SIGNATURE		

A COMPLETED COPY MUST BE RETAINED IN DISTRICT FILE FOR 5 YEARS

THIS IS TO CERTIFY THAT THE ABOVE-NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION, THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR CARGO-ONLY AIRCRAFT.

DESTINATION	SIGNED	DATE
DESTINATION	SIGNED	DATE



EMERGENCY RESPONSE INFORMATION

UN2909, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE ARTICLES MANUFACTURED FROM NATURAL THORIUM, 7

POTENTIAL HAZARDS

HEALTH

- Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents. Packaging durability increases as potential hazard of radioactive content increases.
 - Very low levels of contained radioactive materials and low radiation levels outside packages result in low risks to people. Damaged packages may release measurable amounts of radioactive material, but the resulting risks are expected to be low.
 - Some radioactive materials cannot be detected by commonly available instruments.
 - Packages do not have RADIOACTIVE I, II, or III labels. Some may have EMPTTY labels or may have the word "Radioactive" in the package marking.
- FIRE OR EXPLOSION**
- Some of these materials may burn, but most do not ignite readily.
 - Many have cardboard outer packaging; content (physically large or small) can be of many different physical forms.
 - Radioactivity does not change flammability or other properties of materials.

PUBLIC SAFETY

- **CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover of the North American Emergency Response Guidebook.**

- **Priorities for rescue, life-saving, first aid, fire control and other hazards are higher than the priority for measuring radiation levels.**

- Radiation Authority must be notified of accident conditions. Radiation Authority is usually responsible for decisions about radiological consequences and closure of emergencies.
- Isolate spill or leak for at least 25 meters (75 feet) in all directions.
- Stay upwind.
- Keep unauthorized personnel away.
- Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from Radiation Authority.

- **PROTECTIVE CLOTHING**
- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.

EVACUATION

- **Large Spill**
- Consider initial downwind evacuation for at least 100 meters (330 feet).

- **Fire**
- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

EMERGENCY RESPONSE

- **FIRE**
- Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques.

- Move containers from fire area if you can do it without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.

Small Fire

- Dry chemical, CO₂, water spray or regular foam.

Large Fire

- Water spray, fog (flooding amounts).

SPILL OR LEAK

- Do Not touch damaged packages or spilled material.
- Cover liquid spill with sand, earth or other non-combustible absorbent material.
- Cover powder spill with plastic sheet or tarp to minimize spreading.

FIRST AID

- Call 911 or emergency medical service.
- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.
- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

UN3332, RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, 7, RQ

POTENTIAL HAZARDS

HEALTH

- Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents. Packaging durability increases as potential hazard of radioactive content increases.
- Undamaged packages are safe; contents of damaged packages may cause external radiation exposure, and much higher external exposure if contents (source capsules) are released.
- Contamination and internal radiation hazards are not expected, but not impossible.
- Type A packages (cans, boxes, drums, articles, etc.), identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Radioactive sources may be released if "Type A" packages are damaged in moderately severe accidents.
- Type B packages, and the rarely occurring Type C packages, (large and small, usually metal) contain the most hazardous amounts. They can be identified by package markings or by shipping papers. The threatening conditions may exist only if contents are released or package shielding fails. Because of design, evaluation and testing of packages, these conditions would be expected only for accidents of utmost severity.
- Radioactive White-I labels indicate radiation levels outside single, isolated, undamaged packages are very low (less than 0.005 mSv/h (0.5 mem/h)).
- Radioactive Yellow-II and Yellow-III labeled packages have higher radiation levels. The transport index (TI) on the label identifies the maximum radiation level in mem/h one meter from a single, isolated, undamaged package.
- Radiation from the package contents, usually in durable metal capsules, can be detected by most radiation instruments.
- Water from cargo fire control is not expected to cause pollution.

FIRE OR EXPLOSION

- Packages can burn completely without risk of content loss from sealed source capsule.
- Radioactivity does not change flammability or other properties of materials.
- Radioactive source capsules and Type B packages are designed and evaluated to withstand total engulfment in flames at temperatures of 800 °C (1475 °F) for a period of 30 minutes.

PUBLIC SAFETY

- **CALL EMERGENCY RESPONSE Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover of the North American Emergency Response Guidebook.**

- **Priorities for rescue, life-saving, first aid, fire control and other hazards are higher than the priority for measuring radiation levels.**

- Radiation Authority must be notified of accident conditions. Radiation Authority is usually responsible for decisions about radiological consequences and closure of emergencies.
- Isolate spill or leak for at least 25 meters (75 feet) in all directions.
- Stay upwind.
- Keep unauthorized personnel away.
- Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from Radiation Authority.

- **PROTECTIVE CLOTHING**
- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

EVACUATION

- **Large Spill**
- Consider initial downwind evacuation for at least 100 meters (330 feet).

Fire

- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

EMERGENCY RESPONSE

- **FIRE**
- Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques.

- Move containers from fire area if you can do it without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.

Small Fire

- Dry chemical, CO₂, water spray or regular foam.

Large Fire

- Water spray, fog (flooding amounts).

SPILL OR LEAK

- Do Not touch damaged packages or spilled material.
- Damp surfaces on undamaged or slightly damaged packages are seldom an indication of packaging failure. Contents are seldom liquid. Content is usually a metal capsule easily seen if released from package.
- If source capsule is identified as being out of package, DO NOT TOUCH. Stay away and await advice from Radiation Authority.

FIRST AID

- Call 911 or emergency medical service.
- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.
- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

APPENDIX 10. TRUCK RADIATION LEVEL SURVEY

Schlumberger
Drilling & Measurements

Truck Radiation Level Survey

Truck plate: _____

Origin: _____

Destination: _____

Date: _____

HazMat # _____

E-Journey Trip # _____

Truck is loaded with the following radioactive sources

	Sources (code and serial)	Activity	Contained in <small>(shield or overpack #)</small>
1	_____	_____ GBq	_____
2	_____	_____ GBq	_____
3	_____	_____ GBq	_____
4	_____	_____ GBq	_____
5	_____	_____ GBq	_____

Mark position of sources

Record Background (Bkg.) before loading and readings after loading inside drivers cab and at outer edge of bed as shown *(readings C and D should be in line with the radioactive sources)*

	Gamma	Neutron	Total	Units <small>(delete what does not apply)</small>	
Bkg.	_____ + _____ = _____			mrem/hr	μSv/Hr
A	_____ + _____ = _____			mrem/hr	μSv/Hr
B	_____ + _____ = _____			mrem/hr	μSv/Hr
C	_____ + _____ = _____			mrem/hr	μSv/Hr
D	_____ + _____ = _____			mrem/hr	μSv/Hr

Gamma Survey Meter # _____ Calibrated on _____ (date)

Neutron survey Meter # _____ Calibrated on _____ (date)

Survey Performed by: _____

Print name *Sign*

All sources correctly secured
(Locked/Strapped down) Yes No

Correct Placards in place:

Yes
 No

Yes
 No

Final review (supervisor)

Print name *Sign*

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APPENDIX 12. EMERGENCY RESPONSE PLANS



RADIATION

EMERGENCY RESPONSE PLAN

GUYANA, TRINIDAD AND CARIBBEAN

The authorized and controlled version of this reference document shall be the version published online in the GTC Regulatory Compliance Hub. Users must verify the validity of paper and electronic copies against the controlled version. All obsolete versions must be disposed of accordingly.

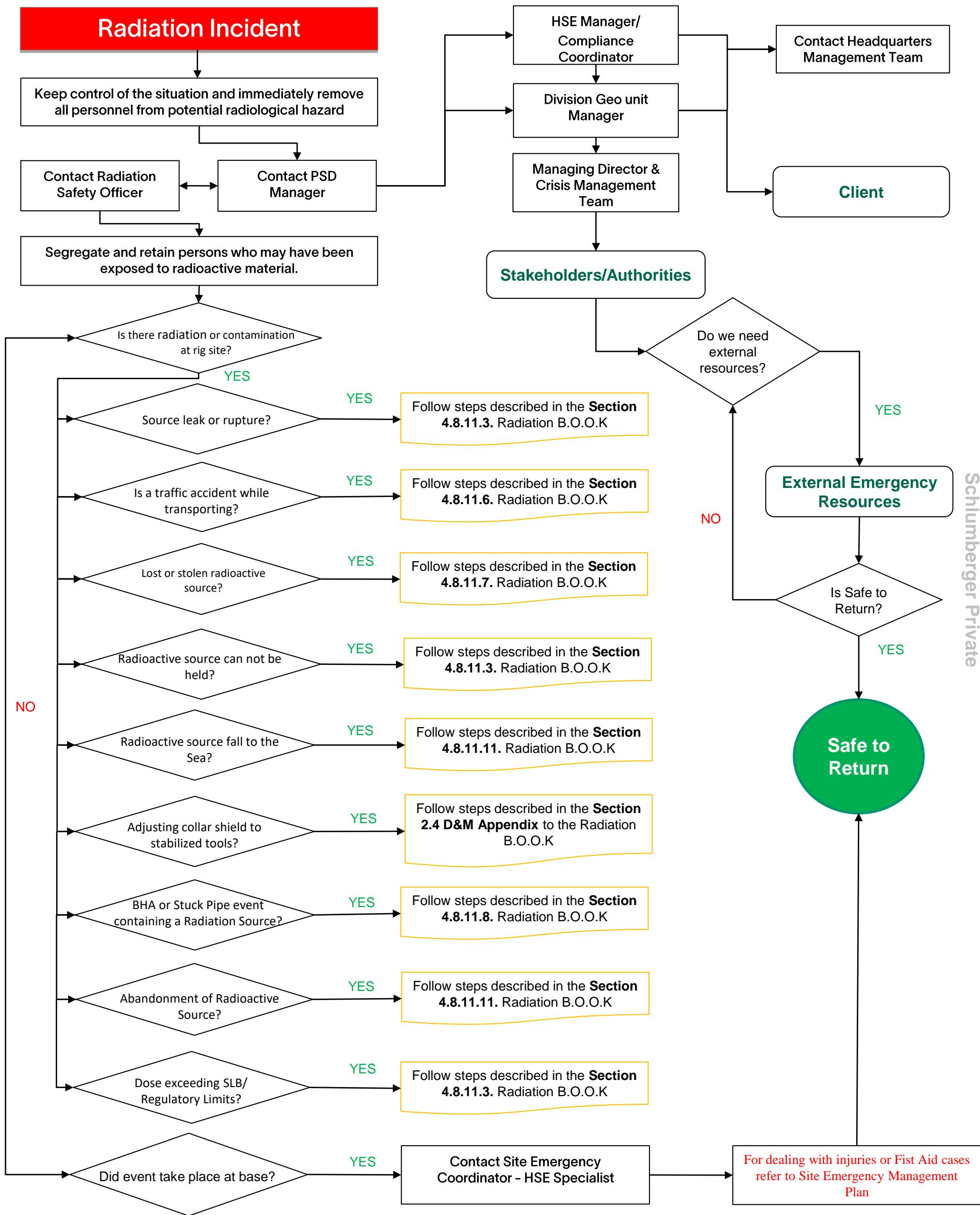
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Revision History

Rev.	Issue Date:	Revision Description	Prepared by:	Verified by:	Approved by:
Rev 0.0	Jan 2021	First Issue	Ciro Alfonso Vanegas	Yuri Mozhaev	Yuri Mozhaev
Rev0.1	March 2023	First revision	Radiation Safety Officers	Maximiliano Zurita	Yuri Mozhaev
This revision approved by			Signed by:		



Radioactive Source – Emergency Management Plan



Schlumberger Private



GENERAL PROCEDURES FOR RADIOLOGICAL INCIDENTS

Leaking or Ruptured Source

When a source has leakage or rupture, the procedures described below must be followed in addition to the procedures previously described. When a ruptured sealed source is suspect, contact the RSO / PSD of the location. Also, contact the GeoUnit Radiation Safety Officer as he could have additional detection equipment sensitive enough to detect low levels of radiation or contamination that could be found if the sealed source were leaking or broken.

If you suspect that a sealed source is leaking or has a break, perform the following procedures:

1. Clear the area of possible contamination.
2. Take a measurement of the area of possible contamination to confirm the extent or scope of the affected area
3. Restrict access to any area where the radiation monitoring is greater than done before work through barricades.
4. Do not allow anyone to drink, eat or smoke in the suspected contaminated area. Any food or drink found in the suspected contaminated area should be isolated for later disposal. No food, drink or smoking material should be brought to the area that is contaminated is suspected.
5. Check the level of radiation of all people within the contaminated area. If you notice contamination, ensure that the person shower / wash as soon as possible and isolate contaminated clothing.

Note

Contaminated clothing should be double-bagged and marked. This mark shall include a warning of the presence of radioactive material and the name of the person who used it.

6. Immediately notify the appropriate authorities.
7. Notify health care facilities if necessary.

Vehicle Accident Including Radioactive Material

If a vehicle carrying radioactive material is involved in a traffic accident that **does not result in a fire**, the company staff in place should review the conditions of the vehicle carrying radioactive material:

1. If obvious damage exists in that part of the vehicle, then the vehicle must be moved and radioactive charge should be inspected considering:
2. If there is no visible damage on the package, the location can move the bulk and without risk of radiological emergency.
3. If the package has a visible damage, the location should monitor the bulk radiation to determine if it can be mobilize.

- The package can not be transported and must be replaced if:

- a) Dose rate is greater than 0.1 mSv per hour at one meter from the package.
- b) Dose rate is greater than 2 mSv per hour on the surface of the package.
- c) Package can be locked and lock is required

- The package can be transported with a Yellow III label if:

- a) Dose rate is less than or equal to 0.1 mSv per hour at one meter from the package.
- b) Dose rate is less than or equal to 2 mSv per hour on the surface of the package.
- c) Package can be locked if a lock is required

- The package can be transported with a Yellow II label if:

- a) Dose rate is less than or equal to 0.01 mSv per hour at one meter from the package
- b) Dose rate is less than or equal to 0.5 mSv per hour on the surface of the package.
- c) Package can be locked if a lock is required

If a vehicle containing radioactive material is involved in a traffic accident, and if it results in a fire, it is mandatory to isolate the vehicle until the arrival of the Radiation Safety Officer, Schlumberger Guyana location shall survey the package with a survey meter to determine if the package can be moved like this:

- The package can not be transported and must be replaced if:

- a) Dose rate is greater than 0.1 mSv per hour at one meter from the package.
- b) Dose rate is greater than 2 mSv per hour on the surface of the package.
- c) Package can be locked and lock is required

- The package can be transported with a Yellow III label if:

- a) Dose rate is less than or equal to 0.1 mSv per hour at one meter from the package.
- b) Dose rate is less than or equal to 2 mSv per hour on the surface of the package.
- c) Package can be locked if a lock is required

- The package can be transported with a Yellow II label if:

- a) Dose rate is less than or equal to 0.01 mSv per hour at one meter from the package
- b) Dose rate is less than or equal to 0.5 mSv per hour on the surface of the package.
- c) Package can be locked if a lock is required



GENERAL PROCEDURES FOR RADIOLOGICAL INCIDENTS

Lost, Missing or Stolen Radioactive Material

The OFS location shall provide the following information if radioactive materials are lost, missing or stolen:

- Date of discovery
- Description of the material (serial number, radionuclide, quantity, chemical, and physical form)
- Date when and where the material was last accounted for
- Results of efforts so far to recover the material
- Potential exposures to non-SLB personnel
- What non-SLB organizations have notified or are aware of the incident

Radioactive source cannot be held

If the source can not be held, this can be due to different reasons:

1. Fishing Head or End Cap are damaged.
2. Handling Tool or Fishing Tool are damaged.
3. BHA stuck above the source

In case of a damaged fishing head, the source should be considered stuck. The emergency collar shield should be placed on the tool and it must be sent to the laboratory on the base. In this case, the shield has a stop collar to be adjusted to fit and depending on whether the tool is stabilized or not.

A fishing tool or handling tool damaged should be replaced with the back up that must be in the wellsite, if there is not a second or additional.:

Wait for one to be sent
Send the tool with shield collar on.

In the event that the BHA is stuck above the source, it is important to determine how large the cap, this will help identify the best way to release the source. A small plug may be moved with high pressure water, but if it is greater than 1 foot thick, it can be displaced with pumping below the tool. In this case it is important to place the shield collar Source before having the BHA or rotary table surface and should make sure whether the tool is stabilized or not, because the shield is adjusted.

Source Radioactive fall to the Sea / Lake

If the radioactive source falls to sea / lake, it is possible that it can not be recovered. The most important factor to be considered is the depth of it, because it might be possible to get support from a team of divers and so locate the box / shielding of the source.

There is a possibility that the box / screen font dipping down to the bottom of the sea, which hinder their recovery, so that the process of abandonment of radioactive source must be discussed with the Field Manager, Radiation Safety Officer and client.

Also, it should consider the cost that involves recovering the source, because it could exceed the cost of acquiring a new, so we must assess the situation and discuss the process of abandonment of such radioactive source.

Adjusting Collar shield to Stabilized Tools

If a stabilized tool is being used, the engineer must ensure that the inner part of the lower collar shield is removed so that the stabilizer is correctly set to the collar shield.



GENERAL PROCEDURES FOR RADIOLOGICAL INCIDENTS

BHA or Stuck Pipe Event that involve a radioactive source

When there is an stuck pipe situation that involved a radioactive source, PSD and RSO must be immediately notify no matter what time of the event is. BHA should be tried to be release, but if attempts are in vain, fishing operations must be performed if possible. It is recommended that the source is caught before 100 jar firing or before a drastic operation that increases the risk of not recovering the radioactive source.

Abandonment of a Source

Client Responsibilities for Abandonment of a Source

When abandonment of a radioactive source is imminent, the client is entirely responsible for the following:

- Gaining the approval of the agency issuing the well drilling permit
 - Approval of Ministry of Natural Resources will be required
 - Responsible personnel from client
- Preparing an abandonment plan
 - Responsible personnel from client
 - Responsible personnel from Schlumberger will be: **Ciro Ramirez**
- Informing Well Constructions Guyana of their abandonment plans
- Implementing the plan

OFS Responsibilities for Abandonment of a Source

It is OFS's responsibility, via the GeoUnit RSO, to submit the client's proposal to the radiation-licensing agency for approval. Responsible Person from Schlumberger will be **Ciro Ramirez**

Minimum Requirements for Abandonment

- The minimum requirements for source abandonment are:
- Approval by both the well permitting agency and the radiation-licensing agency
 - Well Permitting Agency for Guyana is GGMC. Focal Point: Tashana Redmond George
 - Radiation Licensing Agency for Guyana is EPA. Focal Point: Tashana Redmond George
- A hydraulic seal, normally a cement plug, 60 meters (200 ft.) long
- A mechanical protection of the source from damage due to further attempts at drilling or deepening (normally a whip stock shoe or other deflection device above the cement plug)
 - Client to review which mechanical devices to be placed above the cement plug
 - This requirement is as per International Atomic Energy Agency (IAEA) - Well logging
 - https://www-pub.iaea.org/MTCD/Publications/PDF/P1879_web.pdf

A plaque at the wellhead will not be installed as the wellhead will be removed in case of well abandonment.

Abandonment Reports

The Schlumberger GeoUnit RSO, in conjunction with the Well Constrictions Guyana location, shall prepare a report each time a source is abandoned and forward a copy of the report and the RMT to the OFS RSO. It will also be distributed to Client

The report shall include the following:

- Date of occurrence
- Source description (serial number, radionuclide, quantity, chemical, and physical form)
- Surface location and identification of the well
- Results of efforts to immobilize and seal the source in place
- Brief description of the attempted recovery effort
- Depth of source
- Depth to top of cement plug
- Depth of the well
- Any other information such as a warning statement contained on the permanent identification plaque
- Agencies receiving a copy of the report

The most important thing in an emergency is to act quickly and efficiently. All accidents without exceptions must be reported immediately by the people involved.



GENERAL PROCEDURES FOR RADIOLOGICAL INCIDENTS

Doses exceeding OFS limits

In addition to reporting doses in excess of OFS limits, the GeoUnit RSO shall ensure that higher than normal exposures of employees or nonemployees are investigated. The GeoUnit RSO, in conjunction with the OFS location, shall prepare a report for each of these incidents and shall forward a copy to the OFS RSO. The report shall include the following:

- Date of occurrence
- Summary of the incident
- Name of the individuals exposed, their doses, and the method used to determine the doses
- What actions have or will be taken to prevent a future incident
- Agencies receiving a copy of the report

Information gathering for Public Exposures

If an exposure to any member of the public occurs (e.g., rig workers), then information must be gathered to allow the calculation of the potential dose. As soon as the rig floor is secured, and before any involved personnel disperse, the necessary information to estimate doses received must be gathered.

This is the necessary information:

- The location (s) of source (s) that caused the exposure to the public.
- If possible, direction (orientation) of sources— The gamma-ray emission is highly directional.
- Distance and orientation from the source (s) of each exposed person.
- Estimated length of exposure of each person (if anyone moved, then the time in each position) and whether or not any individual touched, handled or picked up a source.
- Personal details of each person exposed (i.e., name, age, job description, employer, social security number, contact telephone number and mailing address)— These details will be necessary for any formal report made to the employers, operating company and regulators, if required, assign a letter code to each person exposed and, in the documentation, refer to these as Employee A, B, etc., while keeping the list of identities separate.
- A plot plan (in scale) should be drawn of the rig floor, with the BHA (sources) orientation indicated. The precise position of each employee with respect to the BHA should be indicated on this plan.

Avoid discussions

While gathering exposure information from the rig personnel, be careful to clarify that you are required to report this information to management, but that this in no way implies that any of the persons were exposed to a dangerous dose of radiation. Do not make any statements of dose estimation to these persons or any one else on the rig. Advise all persons that careful dose calculations will be made and communicated in a timely manner.

Preliminary Dose station (For internal use only)

The preliminary estimate dose by field staff should only be communicated to management of Schlumberger. It should not be communicated to the customer, rig crew, individuals with potential exposure or any other individual who does not belong to the Management of Schlumberger and does not have an express approval of GeoUnit RSO.

Refer to the Radiation Standard B.O.O.K : Policies and Procedures. Section 4.8(Safe Operating Requirements) for purposes of verifying the operation of these calculations.

Communication with the client, exposed personnel, and regulators

All follow-up communications with clients and exposed personnel shall be approved and coordinated by OFS GeoUnit QHSE, following verification of the field personnel's reports and dose estimates. Such follow-up discussions shall not be carried out by field personnel, but at a suitable management level determined by OFS GeoUnit management.

Where doses received by third parties warrant further action such as medical follow up, these efforts shall be managed by OFS QHSE management within the requirements of local regulation and corporate policy and the legal department at the GeoUnit level and above.

Where required, a full report shall be prepared by the GeoUnit QHSE Manager/RSO and forwarded to the regulatory authorities, within the reporting procedures of that GeoUnit.

The most important thing in an emergency is to act quickly and efficiently. All accidents without exceptions must be reported immediately by the people involved.