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|  | **Operational Safety Procedure Form**  **(See** [**ES&H Manual Chapter 3310 Appendix T1 Operational Safety Procedure (OSP) and Temporary OSP Procedure**](http://www.jlab.org/ehs/ehsmanual/3310T1.htm) **for instructions.)** | **Click**  For Word Doc |
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| **DEFINE THE SCOPE OF WORK** | | | | | | | | | | | |
| Title: | **Cryomodule Test Facility Operational Safety Procedure** | | | | | | | | | |  |
| Location: | | | Cryomodule Test Facility, Bldg. 58 | | | | | **Type:** | | **OSP**  X  **TOSP** |  |
| Risk Classification  (per [Task Hazard Analysis](https://www.jlab.org/ehs/ehsmanual/Glossary.htm#THADef) attached)  (See [*ESH&Q Manual Chapter 3210 Appendix T3 Risk Code Assignment*](http://www.jlab.org/ehs/ehsmanual/3210T3.htm).) | | | | | Highest Risk Code Before Mitigation (3 or 4): | | | | | 4 |  |
| Highest Risk Code after  Mitigation (N, 1, or 2): | | | | | 1 |  |
| Owning Organization: | | | | SRFOPS | | Date: |  | | | |  |
| Document Owner(s): | | | | Michael Drury | |  |
| Document History (Optional) | | | | | | | | | | | |
| Revision: | | Reason for revision or update: | | | | | | | Serial number of superseded document | | |
|  | | Document Expiration | | | | | | | SRF-15-47433-OSP | | |

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| **ANALYZE THE HAZARDS** | |
| 1. **Purpose of the Procedure –** Describe in detail the reason for the procedure (what is being done and why). | |
| The purpose of this procedure is to facilitate the safe operation of the Cryomodule Test Facility during operation and testing of RF structures and cryogenic devices. | |
| 1. **Scope –** include all operations, people, and/or areas that the procedure will affect. | |
| This OSP addresses the activities associated with the Testing of RF structures and cryogenic devices in the Cryomodule Test Cave Facility with the dual output 1497 MHz 13 kW klystron system and with the eight individual 1.3 GHz solid state amplifiers (SSA’s).  Individual tests of cryomodules or other equipment which require operating parameters outside the scope of this OSP and existing hazard analyses will be dealt with on an individual basis by separate TOSP’s. | |
| 1. **Description of the Facility –** include floor plans and layout of a typical experiment or operation. | |
| The Cryomodule Test Facility, Room 1119, is located in the center of the first floor against the east wall of the Test Lab, Bldg 58 (Figure 1). The facility includes the test area (the Cave), the production cryomodule control room along its north wall, and the labyrinth between the cave and the control room. The shielded area is 18 ft. wide by 20 ft. high by 56 ft. long. The wall shielding is concrete and at least 4.5 ft. thick on all sides, and 3 feet thick on the roof. A vent fan assembly and several small penetrations are located at various positions on this shield.  Access to the test area is through two doors, a concrete door that rises from and lowers through the floor at the west end, and a door and labyrinth at the northeast end. Both doors must be closed to begin preparation for testing. The labyrinth door at the northeast corner will be the primary access and egress used in preparing the test area for testing and must be closed and locked in order to set the interlock system. A ceiling vent exhausts gaseous cryogens in the event of a leak causing a potential oxygen deficiency condition. Above the roof, the sides of the vent are shielded by concrete, and, where appropriate, lead. This shield reduces the radiation exposure in this location to levels consistent with other locations on the roof. The area over the top of the vent is not shielded and may be a radiation area depending on operating conditions.    Figure 1  **Utilities**   * The Cryogenic Test Facility (CTF) supplies liquid and gaseous helium to cool the cryomodule helium vessel and shield. These cryogens will maintain the helium vessel at 2-4K and the shield at ~ 45K. The cryogenic equipment is located at the back of the cave, outside the magnetic shielding. * High power RF will be coupled into the test cryomodule from the dual output 13 kW 1497 MHz RF-power system, on or all of the eight 1.3 GHz SSA’s or from another RF amplifier that can be operated in accordance with the procedures for connecting alternative RF amplifiers on pages 15. * Gaseous nitrogen feed is available at the front of the cave by the rollup door. | |
| 1. **Authority and Responsibility:** | |
|  | * 1. **Who has authority to implement/terminate** |
|  | * **Facility Manager** – This responsibility is assigned by the Department head of the ISRFST department. This individual has ownership of the facility and has overall responsibility for safe configuration and operation of the facility. * **Test Coordinator** – The test coordinator is assigned by either the Facility Manager or the Department head of the SRF Institute. The Test Coordinator has overall responsibility for a given test plan (such as a Cryomodule Acceptance Test). The Test Coordinator is responsible for planning and executing the test plan, ensuring that operations are carried out in a safe manner, directing the activities of system operators while they are on shift, and insuring that the facility is properly staffed. The Test Coordinator must be cognizant of the status of the facility and any device under test in the facility for the duration of the Test Plan. The TC must have a thorough understanding of the configuration and operation of the relevant systems required for the execution of the planned experiments. For most routine production testing, the Facility Manager may also serve as the Test Coordinator. |
|  | * 1. **Who is responsible for key tasks** |
|  | * **Principal Investigators** (PI’s) have to demonstrate to the Test Coordinator that the test is appropriate. The PI must also ensure that the System Operator has the ability to perform the test. The PI or approved designee must be on call while the respective test is being performed. * **RF System Operators:** They are to be authorized by the Facility Manager. They assist the Principal Investigators in the execution of tests and the changing of system configurations. They must have a thorough understanding of the configuration and operation of the PSS and MPS systems, as well as the configuration of the MPS and RF systems required for the execution of the planned experiments. They should also have a general understanding of the interactions of the cryogenic systems with the specific RF tests. They are responsible for safe operation of the facility and have the authority to stop any experiment if they feel that there is unnecessary potential to damage equipment or if there is an elevated level of risk of injury. * **Cryogenic System Operators:** They are to be authorized by the Facility Manager. They assist the principal investigators in the execution of tests and the changing of system configurations. They must have a thorough understanding of the configuration and operation of the cryogenic systems required for the execution of the planned experiments. They should also have an understanding of the interactions of the specific RF tests with operations of the cryogenic systems. They are responsible for safe operation of the facility and have the authority to stop any experiment if they feel that there is unnecessary potential to damage equipment or if there is an elevated level of risk of injury. * **Duty Operator:** The Duty Operator is the individual System Operator who has been assigned to be responsible for operations on a specific shift. The Test Coordinator assigns the Duty Operator. The Test Coordinator assumes this responsibility during unattended periods of operation such weekends or nights. * **Visiting Operators** are approved by The Test Coordinator to assist PIs in the execution of tests and the changing of system configurations. When using high power RF systems, their activities are to be directed and closely monitored by the Duty Operator. * **The Radiation Control Department** will provide radiation survey support as well as maintenance support of any radiation monitoring equipment that is associated with Personnel Safety. * **Industrial Hygiene** shall provide RF survey assistance upon request. * **The Group Leader of the Safety Systems Group** (SSG) or his designee is the owner of the Personnel Safety System (PSS). |
|  | * 1. **Who analyzes the special or unusual hazards** (See [ES&H Manual Chapter 3210 Appendix T1 Work Planning, Control, and Authorization Procedure](http://www.jlab.org/ehs/ehsmanual/3210T1.htm)) |
|  | Task Hazard Analyses (THA’s) for any Test Plans that require operation of the facility in a manner that is outside the scope of this OSP and existing THA’s will be executed by the Facility Manager acting in concert with the relevant Subject Matter Experts (SME’s):  SME’s will include but are not limited to the following individuals or their designees:   * D. Arenius – Cryogenic Safety * Safety Systems Group Leader – PSS and ODH Monitoring * R. Nelson – RF Safety * V. Vylet – RadCon * T. Menefee – Emergency Manager * S. Dutton – Safety Warden * Any ESH&Q staff with relevant expertise |
|  | * 1. **What are the Training Requirements** (See <http://www.jlab.org/div_dept/train/poc.pdf>) |
|  | MED13 – ODH-2 & Respirator medical certification  SAF103 – Oxygen Deficiency hazards.  SAF104 – Lock, Tag, Try  SAF210 – 5-Minute Escape Pack use  SAF603A – Electrical Safety Awareness  SAF603N – Basic NFPA-70E Training  SAF800 – General Employee Radiation Knowledge  SAF801 – Radiation Worker I Training |
| 1. **Personal and Environmental Hazard Controls Including:** | |
|  | * 1. **Shielding** |
|  | **Prompt Radiation Mitigation**  The north wall and south wall are solid concrete, 20 feet thick and 4.5 feet thick, respectively. The west wall combines a solid concrete wall, 20 feet thick, and a concrete door 10 feet wide and 8 feet thick that rises from the floor in order to isolate the test area. This west door must be closed before the interlock system described in the next section can be set. The roof is concrete, 3 ft. thick. The east wall is a combination of the solid concrete test lab wall and a cinder block/lead brick barrier that surrounds the cryogenic piping from the Cryogenic Test Facility. The barrier is permanently secured to prevent entry to or from the CMTF area.  The two areas of concern for the shielding are the south wall and the roof. The cryostats will always be oriented such that the cavity axis is oriented parallel to the south wall. Therefore, the shielding required in the south wall is determined by the 90-degree radiation source. This has two effects: the source term is lower and the relative spectral hardness of the radiation source is reduced. The following table summarizes the *unshielded* dose rates: (Note that these calculations were for the CEBAF upgrade geometry, so are additionally conservative with respect to distances from hypothetical source to the vent fan and roll-up door)  **Table 1**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Sustained Dose Rate | |  |  |  |  | | Points of Interest (POI) | |  |  |  |  | | Number | 1 | 2 | 3 | 4 | 5 | | Location | Vent Fan Assy | Roof | VTA Wall | Door/Labyrinth | Main Rollup Dr | | Distance, cm | 1024 | 664 | 434 | 343 | 1030 | | Source angle, deg. | 40 | 90 | 90 | 40 | 0 | | **Unshielded** |  |  |  |  |  | | Photon, r/h | 1.86E+01 | 1.41E+01 | 3.29E+01 | 3.82E+01 | 2.83E+02 | | Neutron rem/h | 1.66E-04 | 3.95E-04 | 9.23E-04 | 1.48E-03 | 1.64E-04 | |  |  |  |  |  |  | | Total | 1.86E+01 | 1.41E+01 | 3.29E+01 | 3.83E+01 | 2.83E+02 |   The CMTF (south) wall consists of four and half feet of concrete. The CMTF roof consists of three feet of concrete. The shielding materials and shielded dose rates at the points of interest are presented in Table 2 and 3 below:  **Table 2**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Concrete** | Thickness | **Steel** | Thickness | **Lead** | Thickness | | **Shielding** | ft | **Shielding** | ft | **Shielding** | ft | | Roof | 3 | Roof | 0.0313 | Roof | 0 | | VTA Wall | 4.5 | VTA Wall | 0.0313 | VTA Wall | 0 | | Vent Fan Assy | 2 | Vent Fan Assy | 0.0313 | Vent Fan Assy | 0.33 | | Door Labyrinth | 0 | Door Labyrinth | 0.0313 | Door Labyrinth | 0 | | Main Rollup Dr | 7.5 | Main Rollup Dr | 0 | Main Rollup Dr | 0 |   **Table 3**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Shielded** |  |  |  |  |  | | Sustained Dose Rate | |  |  |  |  | | Points of Interest (POI) | |  |  |  |  | | Number | 1 | 2 | 3 | 4 | 5 | | Location | Vent Fan Assy | Roof | VTA Wall | Door Labyrinth | Main Rollup Dr | |  |  |  |  |  |  | | Photon, r/h | 5.67E-03 | 3.79E-02 | 5.14E-03 | 1.72E-04 | 3.45E-03 | |  |  |  |  |  |  | | Neutron rem/h | 1.23E-05 | 6.35E-06 | 1.01E-06 | 1.03E-04 | 2.22E-17 | |  |  |  |  |  |  | | Total | 5.68E-03 | 3.79E-02 | 5.14E-03 | 2.75E-04 | 3.45E-03 |   The steel shielding is associated with the steel cage around the inside of the CMTF. The concrete and lead shielding around the vent fan assembly was redesigned to minimize weight and provide shielding consistent with other locations outside the shielding.  ~~P~~revious experience tells us that it is reasonable to invoke a duty factor (DF) for CMTF operations. The DF is a fraction based on the time that an activity actually occurs divided by the time that it can occur. The overall DF is the product of these fractions. For example, a cavity under testing does not continuously experience the full gradient assumed in the radiation source term calculation. The radiation source term is also intermittent. This will affect the instantaneous radiation levels over the nominal one-hour integration time used to decide whether administrative controls, such as postings and signs, are needed. In addition, the cavity testing does not occur continuously throughout the entire work year. There is a non-trivial cool-down time associated with each cryostat that is tested, and the bulk of testing time is not at high gradients. In addition, some fraction of high power operations are necessarily pulsed at varying duty factors. Relative to the conservative source term estimates, we estimate a duty factor of 0.01 during the period of testing this cryomodule.  The product of these duty factors should ensure that the integrated radiation doses outside the south wall and the roof are maintained less than 250 mrem yr-l, the JLab shielding design goal. For example, 2000 hr y-l x 5.68 mrem hr-1 x 0.01 DF = 114 mrem yr-l. Note that this result is greater than the limit for unmonitored personnel, and that areas on the roof exceed 250 mrem yr-1, assuming dose rates calculated above are sustained continually during operations. This is a very conservative assumption and is addressed by both administrative postings and area monitoring (see Section 5.3 below).  **New Mitigations for LCLS II Cryomodules**  LCLS II cryomodule testing will include simultaneous operation of all eight cavities. This and experience with the C100 cryomodules has prompted a new RadCon assessment. This has led to new mitigations.  New shielding has been added above the roll up doors as shown in Figure 2.    Figure 2: New Shielding Above Doors  Shield 1 above Door 2 is 208 cm x 64 cm thick and Shield 2 above Door 3 is 100 cm x 100 cm thick. Door 2 will continue to be the primary door. Door 3 is considered to be the backup.  Additional lead shielding will be added around the fan stack opening on the roof of the Cave. The new shielding configuration will consist of an inner layer of 2 in. of lead and an outer layer of 15 in. of concrete on all four sides of the fan stack opening. This added shielding is a requirement for testing of LCLS II cryomodules. The existing shielding configuration is sufficient for testing of any C20 or C50 style cryomodules.  Furthermore, the roof will be posted as a Radiologically Controlled Area (RCA) at the start of LCLS II cryomodule testing. This posting will remain in place for the duration of the LCLS II project.  The Vertical Test Area will be permanently posted as an RCA.  Local shielding may be used inside the Cave to restrict direct line of sight from the cryomodule to penetrations connecting the CMTF and VTA.  **Activation**  High-gradient cryomodules such as C-100 and similar designs contain cavities that have shown the potential to produce radio-activation when operated at high power. Under certain conditions, the energy of the photon field produced by field emitted electrons may exceed the threshold for giant resonance photo-nuclear interactions. These interactions result in the emission of neutrons and the production of residual radioactivity. This phenomenon is difficult to predict. However, the onset of the condition is easily detectable by means of neutron radiation monitoring in the vicinity of the cryomodule.  See section 5.3 for protocols to respond to this condition. |
|  | * 1. **Interlocks** |
|  | Personnel Safety System The CMTF personnel safety system is composed of the following subsystems:   * Access Control System * Safety Interlock System * Oxygen Deficiency monitoring system   Operation of the PSS is divided into four modes:   * Open * Sweep * Ready/Sweep Complete * RUN   RF power derived from the klystron source, SSA, or from other RF amplifier (see Procedure on Page 15) may only be supplied to the cryomodule in the CMTF when the test cave is in RUN mode.  In order to conduct CMTF operations, the PSS must have a current certification. Certifications are scheduled by the Safety Systems Group and must be performed every 6 months. If the Principal Investigator is unsure of the certification status of the CMTF or associated RF systems, they may contact the Safety Systems Group Leader. Devices that are not certified shall be administratively locked and tagged by the Safety Systems Group.  Procedures for operation of the CMTF personnel safety system are given in the CMTF PSS Operator manual.  Configuration Control:  All PSS cable, conduit, and control devices are labeled. Only Safety Systems Group personnel may access these devices.  Devices that are owned by the Safety Systems Group   * AC Contactor in Control Room AC301 * AC Contactor in Test Cave AC302 * AC Contactor on Mezzanine above Test Cave AC303   Certain devices that are critical for safe CMTF operation, such as RF high power amplifier power supplies, are interfaced to the PSS but are not owned by the Safety Systems Group. The safety function of these devices still falls under PSS configuration control.  Devices not owned by the safety systems group but under PSS configuration control:   * Dual 13kW / 1497 MHz klystron power supply PSS interlock chain * 1.3 GHz SSA’s * Waveguide Shutter WS01 * Waveguide Shutter WS02 * Waveguide section between the 1497 MHz klystron and the waveguide shutter switches.   The devices in the listed above shall have a PSS configuration control sticker. The sticker instructs anyone that may want to disconnect the device to first contact a member of the safety systems group.  As an alternative to the automated safety interlock system, the safety systems group may maintain configuration control through the use of administrative lock and tag and the PSS jumper request system. Administrative lock and tag may only be used to render a device Off/Safe. Administrative lock and tag and jumpers used for bypassing the normal PSS configuration of a device may only be applied by a member of the safety systems group. |
|  | * 1. **Monitoring systems** |
|  | **Radiation Mitigation**  Table 3 indicates values that result in administrative actions such as radiation area posting and access controls to minimize exposure. Location number 2 on the CMTF Roof approximately represents a maximum radiation dose rate for the roof. Administrative controls (e.g. posting as a Radiologically Controlled Area or Radiation Area) may be applied to limit access to portions of the roof until radiation monitoring proves that they are otherwise unnecessary. Additional shadow shielding will be used, if needed, to reduce the intensity of radiation oriented towards the labyrinth on the northeast end of the test area. An active area radiation monitoring system, frequent surveys, and operations log reviews will be conducted to ensure that the dose to monitored personnel is less than 250 mrem/yr and unmonitored personnel is below 10 mrem/yr. Passive integrating dosimeters at key locations will be used to provide a record of dose. If either of the administrative goals above appear to be in jeopardy of being exceeded, further controls will be established or documented justification to exceed them will be produced. The access points will be posted and controlled in accordance with the Jefferson Lab EH&S Manual and Radiation Control Manual.  Some scattered radiation (through cable trenches, penetrations, etc.) may be present outside even the thickest parts of the shielding. Consequently, the Radiation Control Department (RadCon) will evaluate the need for shielding and/or active radiation monitors outside the test area where there are trenches, joints or cracks between concrete walls, doors, etc. or other shielding discontinuities. Careful placement of shielding and/or interlocked radiation monitors will be used to prevent a "Radiation Area" condition from occurring outside the CMTF. Any removable shielding is inspected and posted as configuration controlled shielding. RadCon verifies the configuration of interlocked radiation monitors and shielding at least annually.  On-line interlocked radiation monitors (CARMs) and associated warning devices (magenta beacons) are installed at access points to the CMTF. On-line radiation monitoring is part of the operating procedures. If the radiation level outside the shielding should exceed administrative trip points, the radiation monitor will open the guard line that interrupts RF delivery to the CMTF. All radiation detectors associated with the on-line monitoring system shall be properly maintained, calibrated at least annually, and tested during each PSS certification. RadCon, in coordination with the Test Coordinator and Principal Investigator on duty, will perform these actions. Portable survey meters will be used to periodically survey areas outside of the test area. Routine and special surveys will be taken by RadCon staff or Assigned Radiation Monitors and will be coordinated with the operations staff to ensure that the surveys are appropriately coupled to operating conditions. Copies of these surveys will be made available to CMTF operations staff.  **Low power operations in the cave are limited to 1 watt, in order to reduce the hazard of ionizing radiation.**  **CARM Alarm Response**  CARM alarms will terminate radiation-producing activities in the CMTF. In the event of a CARM alarm, the Principal Investigator (PI) or Duty Operator shall notify (RadCon) through the duty phone 757-876-1743 and discuss the operational activities that preceded the alarm. The Test Coordinator should also be notified. RadCon staff may require a supplementary radiation survey as radiation producing activities recommence. An ARM, if available, may conduct the radiation survey and report the results to the Radiation Control Staff. RadCon staff will address the results of the radiation survey with the Test Coordinator, PI and/or Duty Operator and discuss the mitigating measures, if necessary, for continued operation. The Test Coordinator will then determine when operations may resume.  **Neutron CARM Alert Response**  One neutron radiation detector in the cave is configured to produce an “alert level” alarm in the control room. This alarm will occur if the neutron levels in the vicinity of the cryomodule exceed 0.5 mrem/hr. This alarm will NOT terminate the test. The operator may acknowledge the alarm to silence the audible annunciator. When this condition occurs, the operator shall place signage prominently at the PSS console stating “**Contact RadCon at 876-1743 Survey required**” and make an appropriate elog entry copied to [hamlette@jlab.org](mailto:hamlette@jlab.org) and [welch@jlab.org](mailto:welch@jlab.org) and to the Test Coordinator. Furthermore, the Operator will place identical signage on the cryomodule during the next available access. The Test Coordinator must contact RadCon prior to removal of the cryomodule from the cave so that a survey for activation can be performed. The communications should be made far enough in advance to facilitate coordination of the survey. Fixed Oxygen Deficiency Hazard (ODH) Monitoring and Alarm System Oxygen monitors are located in the test cave at multiple levels to detect both helium and nitrogen gas leaks. Oxygen levels below 19.5% will trigger ODH alarms in the CMTF control room and the Test Cave. ODH alarms will also activate the Test Cave exhaust fan. |
|  | * 1. **Ventilation** |
|  | Exhaust Fan in the roof of the CMTF Test Cave is activated when an ODH alarm is triggered. This is designed to facilitate the venting of cryogenic gases. |
|  | * 1. **Other (Electrical, ODH, Trip, Ladder)** (Attach related Temporary Work Permits or Safety Reviews as appropriate.) |
|  | The potential hazards associated with the cave operations include electrical/electrocution, non-ionizing radiation (RF), ionizing radiation, vacuum, ODH, and material handling concerns. These hazards and their mitigation are covered in the attached Task Hazard Analysis. Hazard Mitigation Safe operation of the facility is accomplished through the use of a combination of engineering and administrative controls:   1. Radiation shielding and monitoring (covered in 5.1 and 5.3) 2. Personal Dosimetry monitoring for staff who must enter Radiologically Controlled Areas. 3. A Personnel Safety Interlock System (PSS). (covered in 5.2) 4. Provision of suitable hand held radiation monitors for periodic verification of shielding effectiveness. 5. Oxygen deficiency monitoring system. 6. Training for staff that must enter ODH areas. 7. Personal oxygen monitors and 5-minute escape packs for staff that must enter ODH 2 areas. 8. Detailed operational procedures under which all experiments are conducted by qualified staff scientists and engineers. 9. Several PSS emergency kill switches located in the test cave and in the control room. Activation of any of these kill switches releases the mag lock on the back door, opens the shield door and removes the permit from the high power RF sources’ high voltage power supplies. 10. LOTO procedures for specific tasks.   Personnel training/qualification:   * ODH 2 medical required for accessing ODH 2 areas. * ODH training required for accessing the test cave. * Radiation Worker I required for accessing Radiologically Controlled Areas. * PSS system training is required for System Operators, Principal Investigators and the Test Coordinator. * General Employee Radiation Training is the minimum required for Visiting Operators.  ODH Rating for the Cave  |  |  |  |  | | --- | --- | --- | --- | | **Conditions** | **Rollup Door** | **First Floor** | **Mezzanine** | | No liquid in Cryomodule, No U Tube Stabbed | Open | ODH 0 | ODH 2 | | No liquid in Cryomodule, No U Tube Stabbed | Closed | ODH 1 | ODH 2 | | Cryomodule in Cave with liquid, U Tube Stabbed | Open | ODH 1 | ODH 2 | | Cryomodule in Cave with liquid, U Tube Stabbed | Closed | ODH 2 | ODH 2 |   Table 4  ODH assessment, **JLAB-TN-07-066,** is attached. |
| 1. **List of Safety Equipment:** | |
|  | * 1. **List of Safety Equipment:** |
|  | A video camera is positioned with a monitor located at the back access door so that personnel can see the status of the cryomodules and therefore the ODH status before entering the cave.  The personal escape packs and oxygen monitors required for ODH 2 are located in the CMTF Control Room. They are maintained by the Safety Lab.  The Test Coordinator must verify that a clear pathway exists around the cryomodule prior to cool down and at the beginning of each day in which a cryomodule with u-tubes stabbed is in place in the Test Cave. |
|  | * 1. **Special Tools:** |
|  | N/A |

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| **DEVELOP THE PROCEDURE** | |
| 1. **Associated Administrative Controls** | |
| General **Operating Protocol**  The following are general operating guidelines to be followed when using the test area for radiation producing experiments. Refer to the Conduct of Operations document for details.  One qualified System Operator, normally the Duty Operator, must be present in the facility during all high power RF operations. Their names are displayed on the control desk and entered in the CMTF electronic logbook.   1. Only authorized personnel shall be permitted to enter the test area to make changes in the apparatus. Authorization must be obtained from the Duty Operator, Principal Investigator or Test Coordinator. 2. The Duty Operator is responsible for ensuring safe operation in accordance with the OSP during attended high power RF operations. All personnel entering any Radiologically Controlled Areas shall carry Personal Dosimetry. 3. Any staff member has the responsibility to report to the Principal Investigator or the Duty Operator on issues of safety. If there is no Duty Operator assigned at the time of the event, the staff member shall contact the Test Coordinator, Facility Manager or their designee. An on-call list is posted in the control room to address off-hour conditions. If the issue cannot be resolved at this level, operation shall cease until such time as the issue is resolved. 4. Response to any emergency, accident condition, or injury shall be coordinated with the site security, phone extension 5822. 5. The control room must be attended when high power RF is on. High voltage operations may be left unattended for brief break periods. (See Table 5 for Staffing Requirements.) 6. One-person operation of the cryomodule test facility is permitted from the control room or in the cave when the cave ODH status is ODH 0. 7. The Test Coordinator or his designee must be on call for emergencies.   **Cryomodule test cave waveguide shutter WR650 (1497 MHz) waveguide switch**   1. The waveguide shutter switches located in the test cave provides a second level of assurance that high power RF is not routed to an open waveguide located beyond said shutter. The WR650 waveguide shutter switches are located in the second floor area of the cryomodule test cave. They are approximately 4 feet off of the floor adjacent to the south wall. One switch removes power from cavities 1, 3, 5 and 7. The second switch removes power from cavities 2, 4, 6, and 8. Cavity 1 is on the equipment door end (west) of the cryomodule test cave. These shutters are not currently used as LOTO points. When it is necessary to work on an open waveguide, LOTO must be applied directly to the circuit breakers controlling AC power to the high power amplifier in question.   Post High Power RF testing (Shutdown):   1. 1497 Klystrons    1. First, change state of Klystron Power Supply to “RF Off”, then to “High Voltage Off”.    2. Locate the AC circuit breaker panel behind the 1497 MHz racks and switch to the “Off” position and lock out with administrative lock. See Figure 3. 2. 1.3 GHz SSA’s    1. First, change state of SSA to “RF Off”, then to “High Voltage Off”.    2. Locate and open the 480 VAC breaker on the front of the SSA in use and open. See Figure 4    3. Locate the AC circuit breaker panel behind the last pair of SSA’s and switch to the Off position. Lock out with administrative lock. See Figure 5   20160712_100842a  Figure 3: 1497 HPA AC Circuit Breaker  20160712_100805a  Figure 4: Front Panel 1.3 GHz SSA  20160712_100730a  Figure 5: Breaker Panel for SSA's Procedure for connection and operation of TWT or other RF amplifierCertain tests will require the use of an RF power source other than the 1497 MHz systems. These sources would include the TWT amplifiers that are able to operate at 2.8 – 3.2 GHz. These amplifiers are capable of exceeding the 1 Watt limit. There are three sets of AC outlets that are interlocked to the PSS. These interlocked AC contactors provide a way to interlock amplifiers that are external to the CMTF to the PSS. All of the interlocked contactors provide both 120VAC and 208 VAC power.The three AC contactors are designated:  1. AC301: Located in the CMTF Control Room on the back wall between the two sets of equipment racks.    1. The outlets are labeled SNSP1/14 (120VAC) and SNSP1/33 (208 VAC) 2. AC302: Located inside the Cave in the Southeast corner inside the shielding enclosure. 3. AC303: Located on the Mezzanine above the Test Cave near the 20 kW, 805 MHz klystron stand.   **RF Amplifier connected to AC302 (Test Cave) or AC303 (Mezzanine)** Locate the RF Power source in proximity to the appropriate contactor.  1. While the CMTF Safety System is in the Open mode:    1. Connect RF Amplifier output to Device Under Test through existing waveguide systems (Mezzanine), through RF cables to an input coupler (Test Cave) or through appropriate patch panel connector (Control Room).    2. AC302 and AC 303 must be connected to an existing AC outlet through the attached power cables.       1. AC302 must be connected to the outlets labeled L1400/31 for 120VAC and L1400/20 for 208VAC. These outlets are located on the wall directly below the AC302 enclosure. They are marked with yellow tape.       2. AC303 must currently be connected to AC power through the use of a portable transformer (Big Bertha).    3. Connect the RF Amplifier’s AC power cable to the appropriate outlet on one of the contactors. 2. Connect drive signal to RF Amplifier through RF crash switch in RF Interlock Switch Box in the Control Room. 3. The RF crash switch must be pushed in (for open circuit). 4. Make an entry in the electronic logbook (Pansophy) detailing actions taken. 5. Sweep the Test Cave and bring PSS to Run mode.   **RF Amplifier connected to AC301 (CMTF Control Room)** While the CMTF Safety System is in the Open mode:  * 1. Connect the Amplifier’s power cable to either the 120 V or 208 V outlets. The outlets are located on the back wall of the control room between the two sets of equipment racks. They are labeled, SNSP4/33 and SNSP1/34  Connect the amplifier’s RF output to the appropriate patch panel connector.  * 1. Connect the drive signal from a preamplifier or other device to the amplifier in the CMTF Control Room via the RF crash switch in the RF Interlock Switch Box.  RF crash switch must be pushed in (circuit open).  1. Make an electronic logbook entry detailing the above actions.  Sweep the cave and bring the PSS into Run mode.  1. Turn on amplifier 2. Pull out RF crash button (closed circuit) when ready to drive amplifier.  Begin testAfter completion of tests:  * 1. Push in RF Crash button.   2. Turn off amplifier   3. Bring PSS into Open mode   4. Disconnect RF drive and RF output cables from amplifier   5. Disconnect power cable from AC contactor outlet.  1. Make another electronic logbook entry detailing action listed above.   **Waveguide / Hardline Installation / Removal**   1. Before working on open waveguide or hardline (connect / disconnect) AC Supply Power to either the 1497 MHz Klystron Power Supply or the 1300 MHz SSA’s must be locked out:    1. AC Breaker Panel for the 1497 MHz system is located behind the klystron racks (See Figure 3)    2. AC Breaker Panel for the 1300 MHz system is located behind the last set of SSA’s (See Figure 5) 2. When closing or opening a disconnect breaker and disconnecting the power plug, use proper PPE:    * + 1. **Use safety glasses,**        2. **Heavy Duty Leather Gloves**        3. **A Long Sleeve Natural Fiber or Fire Retardant Long Sleeve Shirt**        4. **Long Pants (made of natural fibers)** 3. Open the breaker for the 1497 MHz system or for the specific 1300 MHz SSA. 4. Check the VVU associated with the breaker to insure that power is removed.    1. VVU for the 1497 MHz system is located on the front of the klystron power supply rack    2. VVU’s for the 1300 MHz systems are located next to the SSA breaker panel (See Figure 6) 5. Each worker must apply a personal lock to a hasp o the breaker in question.   **20160712_100730a**  Figure 6: Breaker Panel for 1300 MHz SSA's  **Waveguide Integrity**  Before Power can be applied to either of the HP RF systems   1. Waveguide / hardline connected to the SSA or klystron output must be terminated by either:    1. Shorting plate    2. Load    3. Reconnected to waveguide / hardline network 2. After completing work on waveguide or hardline, all waveguide / hardline joints that are upstream of the Cave penetrations must be surveyed for RF leakage.    1. RF Survey of Waveguide       1. Turn on the SSA Main Power       2. Close Front Panel Breakers       3. Adjust RF drive until the Forward Power is approximately 100 Watts (by power meter readout).       4. Using the calibrated RF survey meter provided by ESH&Q, survey all waveguide /hardline joints and ports between the SSA or klystron output and the termination for RF leakage. To do so, slowly move the probe along the flange joints at a distance of no more than one inch from the surface. If leakage above 1 mW/cm2 is observed, turn off the RF and take remedial action. Successful completion of the RF survey shall be recorded in the CMTF elog. Entry shall include          1. The RF Forward Power reading in Watts          2. The maximum reading observed on the RF survey meter          3. The date and time          4. Name of the survey operator       5. Increase RF drive power slowly until Forward Power is 1 kW. Using the calibrated RF survey meter provided by ESH&Q, survey all waveguide / hardline joints and ports between the SSA Output and the termination for RF leakage. To do so, slowly move the probe along the flange joints or cutoff tubes at a distance no more than one inch from the surface. If leakage above 4 mW/cm2 is observed, turn off the RF and take remedial action. Successful completion of the RF survey shall be recorded in the CMTF elog. Said entry shall include          1. The RF Forward Power reading in Watts          2. The maximum reading observed on the RF survey meter          3. The date and time          4. Name of the survey operator   **ODH Hazard Mitigation in CMTF Cave During Scheduled Electrical Outages:**  The source of the ODH hazard in the cryomodule test cave is the CTF junction box located in the east end of the room and the helium supply end can located in the north-west corner of the magnetically shielded area. The junction box in the east end of the cave cannot be tagged out, because cryogens used in the vertical test area are routed through it. The end can in the north-west corner of the magnetically shielded area is an un-isolatable extension of the junction box. Thus the source of the ODH hazard cannot be eliminated during the time frame that the ODH system is not operational.  The cave shield door is an electrically controlled multi-ton concrete door. The primary power for this door is supplied by a single circuit breaker. This breaker is located in panel MCC-SU and is located on the west wall of the high bay.  **Procedure 1:**  The shield doors will be secured in the OPEN position for the duration of the scheduled outage by administratively locking and tagging out the circuit breakers labeled, “MCC-SU8-SHIELDG DOOR CC1”and MCC-SU9 SHIELD DOOR CC2, in the OFF position, RC=1. **The following procedure applies only to the first two cases in Table 4, “ODH Ratings for the Cave”. There is either no cryomodule in the Cave or a cryomodule with no u-tubes installed.**   1. The SSG Group Leader or his designee shall first ensure the shield doors are in the OPEN position and then apply an administrative lock on the circuit breakers ““MCC-SU8-SHIELDG DOOR CC1”and “MCC-SU9 SHIELD DOOR CC2". 2. Once the lock is applied, the SSG staff shall ensure that the cave door has been disabled by trying to close it using the key. 3. The administrative lock shall not be removed until such time that the ODH system has been returned to service and tested. 4. The administrative lock and tag shall not be removed and the door re-energized until after the ODH system has been re-energized and certified.   **ODH Hazard Mitigation in CMTF Cave During Scheduled Electrical Outages**  **Procedure 2**  **This procedure applies only to scheduled electrical outages during which the second two cases in Table 4 apply. This means a cryomodule is in place in the cave with u-tubes installed.**  When a cryomodule is in the CMTF with U-tubes stabbed, there is no way to reduce the ODH classification to ODH 0. In this case, the ODH status of the facility will be administratively changed to ODH 2 and posted as such, both at the front door and at the rear access door. As a result, anyone who wishes to enter the area will need to be qualified for ODH2 operations and carry a personal oxygen monitor and escape pack (RC=1). Emergency Procedures: a. Oxygen Deficiency   1. In the event of an ODH alarm, all personnel in the test cave, and CMTF control room, shall leave those areas and assemble outside the CMTF control room. Leave the test area immediately by the nearest exit (away from the plume if possible). 2. While remaining outside of the test cave, a qualified System Operator, the Test Coordinator or the Facility Manager shall determine if there has been or is a significant release of cryogens. 3. If they determine that there has not a release of cryogen, the system operator, the Test Coordinator, or the Facility Manager shall summon the assistance the PSS staff member who is on call. The on call list is posted it the control room and in is available in the MCC x7045. 4. If there has been a significant release of cryogens or you are unable to determine that there has not been a release, the System Operator, the Test Coordinator, or the Facility Manager shall summon the assistance of the on-call cryogenic coordinator and the Industrial Hygiene Group.   Contact Information:  **Industrial Hygiene Group 240-0031 (EH&S Cell Phone)**  **On-call Cryogenic Coordinator contact through Guard House ext 5822**  **Contact the Guard House ext 5822 for off hours number**  **ESH&Q Emergency Manager Tina Menefee –ext 5490**  The area should be posted as ODH 4. Only SCBA rescue qualified personnel from the Newport News Fire Dept. may enter an ODH 4 area.   1. If the alarm is found to be false, the System Operator, the Test Coordinator or the Facility Manager may bypass the offending ODH monitor using the procedure in the CMTF PSS Users Guide. Once clear of the area isolate supply of LHe or LN2 and other lines yourself or contacting the cryogenic coordinator.   b. Off Hours ODH Alarm:  The emergency contacts must respond to the ODH emergency following the same procedure used during normal operations.  c. Possible Excessive Radiation Exposure   1. Immediately call RadCon for assistance: 757 876-1743 2. Turn off the high power RF by crashing the PSS system.   d. RF Emergency   1. **Turn off the high power RF by crashing the PSS system.** 2. Page Rick Nelson at 757-584-7185 or Andrew Kimber 757-746-9312 for assistance.   e. Failure of Personnel Safety System  In the event the interlock system or radiation-monitoring system operate improperly or suffer a hardware failure, the Duty Operator will immediately:   * + - 1. Terminate RF operations       2. Notify PSS on call personnel, and Radiation Control Group on-call personnel.   f. Power Outage   1. Cryogenics: cryogenics coordinator will be automatically notified by the guard callback system in the event of power failure. 2. RF: no response required 3. Cryomodule: contact the cryomodule on call personnel.   e. Other Emergency Situations  For emergencies such as injury or fire, please refer to [https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-24400/\*.pdf](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-24400/*.pdf) (Jefferson Lab Emergency Response Procedures) or to the JLAB Emergency Action Card attached to all JLAB phones. | |
| 1. **Operating Guidelines** | |
| Staffing Open Mode  Open Mode requires no staffing of the CMTF. Additional restrictions based on ODH classification may be required. See section on ODH hazard classification. Sweep Mode Operation of the CMTF test cave PSS does not require a safety system operator (SSO).  During the sweep, the test cave is considered to be under ODH 2 conditions. As such, the sweep must be performed by two qualified personnel. Workers must have current training and carry an operational Personal Oxygen Monitor and carry a properly charged 5-minute escape pack when conducting the CMTF sweep. See section 4.4 for required training.  Personnel performing a sweep must have the following qualifications:   * ODH 2 medically qualified * Trained in the use of the personal ODH monitors and 5-minute escape packs * At least one member of the sweep team familiar with the sweep pattern   A copy of the sweep pattern is shown in Figure 7. Instructions for the sweep procedure are given in the CMTF PSS Users Guide. RUN Mode When the PSS is in RUN mode and all high power RF sources are turned off along with any High Voltage supplies, a System Operator must be present in the Test Lab. This person shall check the status of the PSS and RF systems no less than once per hour.  When the PSS is in RUN mode and high power RF is ON, a System Operator must be present in the Control Room.  See Table 5 for detailed staffing requirements. Note: High Voltage refers to the 1497 MHz system. 480 V refers to the 1300 MHz systems  CMTF Sweep  Figure 7 Sweep Pattern used for placing the PSS in RUN mode   |  |  |  | | --- | --- | --- | | **Cave State** | **PSS** | **Staffing Requirements** | | Open  Low Power RF Off | Open Access | Unattended Operations permitted  24 hour on call contact | | High Voltage / 480V Off  High Power RF Off | Run | One operator must check status in control room at least once per hour | | High Voltage / 480V Off  High Power RF Off | Sweep/Arm | Two operators required to complete sweep. | | High Voltage / 480 V On  High Power RF Off | Run | Operator may leave the control room for short breaks (up to 10 minutes) | | High Voltage / 480 V On  High Power RF on | Run | One operator must be present in control room. | | High Voltage / 480 V Off  Low Power RF on or off | Run | One operator must check status in control room at least once per hour | | Low Power RF on | Open Access | Unattended Operations permitted  24 hour on call contact |   Table 5 PSS / Cave States and Staffing Requirements High Power RF Operation The dual 13 kW / 1497 MHz sources as well as any other interlocked RF source may only be operated when the test cave is in RUN Mode.  Exceptions to this rule are allowed for the Warm Window Test Stand located in on the mezzanine. The Standard Operating Procedure for **CEBAF Replacement Warm Window RF Qualification Testing** describes the circumstances under which RF may be produced by the dual 13 kW / 1497 MHz without placing the Test Cave in the RUN mode. Configuration instructions are given in the CMTF PSS Users Guide.  The following are important notes about the interface between the CMTF PSS and high power amplifiers:   * Pushing any crash switch will shut off ALL RF systems. * If any RF system indicates that it is ON/Unsafe before a sweep of the test cave is complete, the PSS will drop to OPEN mode. * The test cave must be in RUN mode in order to operate any PSS interlocked, high power RF system configured to deliver RF to the Test Cave. * An alarm from an ionizing radiation monitor (CARM) or non-ionizing radiation monitor (RF monitor) will trip off any PSS interlocked, high power RF system configured to deliver RF to the Test Cave. Before Operations can resume after a CARM or RF monitor alarm, the PSS must be reset by cycling the key to Ready then back to RUN. * When the PSS is switched from Sweep to RUN mode, there is a 30 second delay before RF can be energized. This timer is to allow anyone caught in the test cave time to activate the nearest crash switch.  On Call Support A member of the SSG group is on call at all times. An SSG on-call schedule shall be posted in the CMTF Control Room. On call support should only be initiated after the Principal Investigator or Duty Operator has attempted to solve the problem and failed. A short troubleshooting procedure is contained in the CMTF PSS Users Guide.   Log keeping All PSS operations shall be logged by the Principal Investigator, or Duty Operator, in the CMTF PSS log book, located at the CMTF PSS console and in the CMTF electronic log (in Pansophy). | |
| 1. **Notification of Affected Personnel (who, how, and when)** | |
| * The front entrance of the Test Cave is posted with signage that indicates the ODH state. * Flashing magenta beacons at front and back of Cave indicate High Power RF and the potential for ionizing radiation. * Blue flashing lights in case of ODH alarm * Audible alarm sounds when Test Cave is placed in RUN Mode * Video monitor at entrance to labyrinth at back of Cave indicates state of cryomodule (u-tube stabbed or not) and ODH state. | |
| 1. **List the Steps Required to Execute the Procedure:** from start to finish. | |
| See Sections 1 and 2 above. | |
| 1. **Back Out Procedure(s)** i.e. steps necessary to restore the equipment/area to a safe level. | |
| See Sections 1 and 2 above. | |
| 1. **Special environmental control requirements:** | |
|  | * 1. **Environmental impacts** (See [EMP-04 Project/Activity/Experiment Environmental Review](https://jlabdoc.jlab.org/docushare/dsweb/View/Collection-1349)) |
|  | N/A |
|  | * 1. **Abatement steps (**secondary containment or special packaging requirements) |
|  | N/A |
| 1. **Unusual/Emergency Procedures** (e.g., loss of power, spills, fire, etc.) | |
| Follow guidance in this OSP or in ES&H Manual as appropriate. | |
| 1. **Instrument Calibration Requirements** (e.g., safety system/device recertification, RF probe calibration) | |
| PSS Certification is required every six months and is carried out by the Safety Systems Group  ODH monitoring sensors are maintained by Safety Systems Group | |
| 1. **Inspection Schedules** | |
| PSS Certification is required every six months and is carried out by the Safety Systems Group.  Shielding and radiation monitoring configuration inspections are conducted every six months by RadCon. | |
| 1. **References/Associated Documentation** | |
| References:  ES&H Manual Sections:   * 6140 Cranes and Hoists * 6210 General Electrical Safety * 6310 Ionizing Radiation Protection * 6315, Environmental Monitoring of Ionizing Radiation * 6420 Radio Frequency and Microwave Radiation * 6540 Oxygen Deficiency Hazard   **Attachments:**   * SOP A-06-003-SOP **CEBAF Replacement Warm Window RF Qualification Testing** * **Conduct of Operations for the Cryomodule Test Facility** * JLAB-TN-07-066 **ODH Risk Assessment, CMTF, Jan 12, 2016** * JLAB-TN-16-010 **Calculation of CMTF Roof Shielding and Radiation Skyshine** * JLAB-TN-16-009 **Shielding Basis of the Cryomodule Test Facility Upgrade** * Bolt Pattern for Waveguide Flanges | |
| 1. **List of Records Generated** (Include Location / Review and Approved procedure) | |
| All data acquired during CMTF operations are stored in Pansophy traveler system and /or Docushare along with folders on the M drive. | |
|  | |

[](https://mis.jlab.org/mis/apps/mis_forms/operational_safety_procedure_form.cfm)

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| **Form Revision Summary**  **Revision 1.3 – 11/27/13 –** Added “Owning Organization” to more accurately reflect laboratory operations.  **Revision 1.2 – 09/15/12 –** Update form to conform to electronic review.  **Revision 1.1 – 04/03/12 –** Risk Code 0 switched to N to be consistent with [3210 T3 Risk Code Assignment](http://www.jlab.org/ehs/ehsmanual/3210T3.htm).  **Revision 1.0 – 12/01/11 –** Added reasoning for OSP to aid in appropriate review determination.  **Revision 0 – 10/05/09 –** Updated to reflect current laboratory operations   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **ISSUING AUTHORITY** | **FORM TECHNICAL POINT-OF-CONTACT** | **APPROVAL DATE** | **REVIEW REQUIRED DATE** | **REV.** | | ESH&Q Division | [Harry Fanning](mailto:fanning@jlab.org?subject=ESH%20Manual%203310%20Appendix%20T1%20Operational%20Safety%20Procedure%20Form) | 12/01/11 | 12/01/14 | 1.3 |   ***This document is controlled as an on line file. It may be printed but the print copy is not a controlled document. It is the user’s responsibility to ensure that the document is the same revision as the current on line file. This copy was printed on 2/7/2018.*** |