

Foreign Material Exclusion Program at CNE CERNAVODA Nuclear Generating Station

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ABSTRACT

In the face of a continuing attention to operations and maintenance costs at nuclear power plants, the future of the industry depends largely upon increasing plant availability and improving operating efficiency. The success in achieving these objectives is dependent upon the success of each plant's equipment maintenance program. Preventing the introduction of foreign materials into a nuclear power plant system or component requires a careful, thoughtful, and professional approach by all site personnel. This paper describes a proactive approach to prevent the introduction of foreign material into systems and components, by providing an overview of technical considerations required to develop, implement, and manage a foreign material exclusion program at CNE Cernavoda Unit 1&2 Nuclear Power Station. It is also described an example of Foreign Material Intrusion which happened during the 2003 planned maintenance outage at Cernavoda Unit #1. This paper also defines personnel responsibilities and key nomenclature and a means for evaluating prospective work tasks and activities against standardized criteria, in order to identify the appropriate level of the required FME controls.

1 INTRODUCTION

Guidelines have been established to prevent the introduction of foreign materials such as residue, dirt, debris, tools and equipment into open systems or components to avoid equipment damage. Plants where FME practices have not been followed have resulted in significant damage and economic loss when materials end up in areas where they do not belong. Pickering B Unit 6 generator, Pickering A liquid zone control system (deteriorated elastomer from the diaphragm valve), Bruce boilers and Point Lepreau heat transport pumps are some examples.

Foreign material that enters systems can cause equipment degradation or inoperability, fuel cladding damage, and high radiation and contamination levels that are spread throughout the plant. Examples exist where a single small machining chip or even a single bristle of a wire brush has caused fuel cladding damage, resulting in high radiation levels and forced outages to replace the leaking fuel. Other cases have occurred where the dust and small stellite particles from valve seat lapping have become activated as they pass through the reactor core, resulting in high radiation, hot spots in piping, and high contamination levels. As a result, great care and many precautions must be taken to avoid the introduction of foreign material into plant systems.

This paper emphasizes a "focus on prevention" attitude for its users. This attitude requires that individuals think through activities before they are performed to prevent the introduction of foreign material. In addition to these conscientious efforts, a number of other key principles and expectations underlie all work to be performed in the plant.

Workers must recognize when they are about to perform an activity that can generate foreign material. Any drilling, cutting, grinding, machining, filing, lapping, and other such activities generate small particles of foreign material that require attention. All foreign material created must be captured

or otherwise contained. Action must be taken to prevent the possibility of spreading the material. The traditional approach of cleaning up afterward is not sufficient to meet this objective.

Workers must be alert to the potential for discovery of foreign material at all times. An initial inspection should be performed prior to opening a sensitive system or component, and any unexpected conditions encountered should be reported immediately to supervisory personnel. Immediate reporting is also required when foreign material exclusion (FME) controls are deemed lost during work task performance. Unless absolutely necessary to establish a safe condition, foreign material that is not immediately retrievable should not be disturbed or recovered until a recovery plan is established.

The intentional introduction of foreign material, such as leak sealing compound, chemicals, or lubricants, requires additional controls to ensure compatibility with the system and to prevent inadvertent spreading of the foreign material.

Finally, the proper management of foreign material in a nuclear power plant is extremely important. It is based upon common sense methods to keep unwanted material out of the systems and to properly deal with it when detected or inadvertently introduced. Well-informed, proactive, and responsible workers are the first line of defence for avoiding a potentially expensive and damaging event that could seriously affect the safety and operability of the plant.

1.1 Definitions

To facilitate a common understanding and application of the information provided in this paper, below will be provided definitions for a number of the more important items or concepts associated with plant foreign material exclusion implementation.

Clean Enclosure A temporary structure erected around the work area to reduce the possibility of introducing foreign material into a system or component. This enclosure can also be used to reduce the spread of radioactive contamination, dirt, and debris to other systems, components, or areas of the station. Examples of enclosures include glove bags, temporary tents, and temporary buildings.

Cleanliness Requirements Plant procedures, industry standards, and regulatory positions that address cleanliness standards to be maintained for systems and associated components in a nuclear power plant.

Fail Safe Material that is too large to fit into a system or component or any item that when introduced into a system or component should not result in any damage and can be easily retrieved. Materials such as tools, eyeglasses, etc., can be made fail safe for the purpose of this definition by securing them with lanyards.

Flush A process employed to remove known or suspected residue, generated during the performance of an operations or maintenance activity, from a system or component by the introduction of a liquid or gas, such as water or air, sufficient to entrain the foreign material and remove it from the system along with the expelled liquid or gas.

FME Barrier Log A log used to record the installation and removal of internal FME barriers. (See the Appendix in this Tech Note for an example of a Barrier Log.)

FME Boundary A physical boundary around a task, generally consisting of a barrier and appropriate signage that visibly identifies a specific area as a foreign material exclusion area. Barriers can consist of rope, fabric curtains, tents, temporary metal walls, wire fencing, FME tape markers, or other similar materials.

Device An internal, retrievable barrier device or external opening cover installed to prevent foreign material intrusion.

FME Log A chronological listing used to account for items that are introduced into a foreign material exclusion area.

FME Monitor (FMEM) The individual responsible for controlling the FMEA when material or personnel control is established, maintaining applicable logs, monitoring work activities, correcting FME problems, and notifying the maintenance or work supervision about any unresolved problems.

Foreign Material (FM) Any material that is not part of the system or component as designed. Examples include dirt, debris, broken or missing parts, oil, slag, tools, rags, chemicals, machine tailings, lapping compounds, grinding particles, paint chips, leak sealing compounds, and any other items that could adversely affect the intended operation, components, or chemistry of the system.

Foreign Material Exclusion (FME) The plant processes and practices for preventing the introduction of foreign material into a system or component.

Foreign Material Exclusion Area (FMEA) A work area or zone requiring specific controls to prevent the introduction of foreign material into systems or components during the performance of maintenance, modification, test, or inspection activities.

Foreign Material Intrusion (FMI) An incident where foreign material has been introduced into a system or component.

Immediately Retrievable Foreign material that visual contact can be maintained with and that can be recovered at once after it enters a system or component.

Lanyard A device used to hold or fasten a tool, material, or other object for the purpose of preventing its loss. Lanyards usually take the form of a rope, string, cord, or other type of restraint and can be attached to any secure object.

Loss of Control (Loss of Integrity) A condition deemed to exist when material enters an open system or FMEA and is not controlled by anyone. Loss of control (integrity) also exists when:

- Unexpected foreign material is found within a system or component.
- Material logged into an FME Area Level 1 cannot be accounted for during FME log reviews or closure activities.
- Material is found within an FME Area Level 1 that was not logged in to an FME log during the time in which that log entry was required.
- Material that cannot be immediately retrieved is introduced into the system or component.
- Internal barriers fail or external covers become damaged or missing while the FMEA is unattended.
- An assembled or disassembled component used within the FMEA is found to be missing parts.
- Foreign material is found within an open air system (for example, fuel pool, open tank, or flooded reactor cavity).

Maintenance Residue Any by-product of maintenance activity, such as chemical deposits from solvents, particles from grinding or filing, wood chips from scaffolding, tape adhesive, and welding or soldering residue.

Mandatory FME List A list, computer code, component, or work activity for which foreign material exclusion is mandatory, such as turbine disassembly, reactor head removal, refuelling, steam generator inspections, and reactor pump seal replacement.

Personnel Control Log A chronological listing used to account for all personnel who enter the foreign material exclusion area.

Pipe Dam A temporary retrievable blocking device installed inside piping systems to limit the spread of foreign material.

Temporary Cover A device for sealing and protecting a system or component from the introduction of foreign material when the system or component is unattended, or during periods of operation with temporary system modifications in use.

2 DEFINING PERSONNEL RESPONSIBILITIES AND KEY NOMENCLATURE

All site personnel share a common responsibility for FME. Any worker, whether an employee contractor, should be able to initiate a stop work order if FME becomes, or is in danger of becoming, compromised.

Preventing the introduction of foreign materials into a system or component requires a careful, thoughtful, and professional approach by all site personnel. Site personnel should observe the following practices:

- Remove loose or non-essential items from the work area.
- Secure essential items with lanyards.
- Install barriers or covers to block openings.
- Inspect tools for potential loose parts, no matter what size, prior to introduction into the FMEA.
- Secure personal items, such as eyeglasses, earplugs, security badges, dosimeters, as well.

The following sections provide information on divisions for FME-related responsibilities at the plant. In addition, specific guidance on task performance is provided for certain levels of responsibility, such as workers, supervisors, and work planners.

2.1 Worker

The worker is responsible for adhering to FME requirements; maintaining the FMEA; using work practices that minimize the introduction of foreign material into a system or component; notifying the supervisor of problems; assisting in establishing or restoring FME controls, and completing work in a timely manner to reduce the time that an open system or component is vulnerable to introduction of foreign material.

2.2 First Line Supervisor

The first line supervisor has the following responsibilities: to review FME requirements with the planner, brief the work group, implement FME requirements and monitor the work site for FME guideline compliance. Also, he has to initiate corrective actions if FME requirements have not been met or if any procedure problems develop.

Other responsibilities include verifying system and component cleanliness prior to final closure, and initiating recovery procedure if material control is lost; providing feedback to planning on problems or good practices; performing a field inspection of the FMEA; reviewing the work package FME requirements to ensure that they are appropriate to the task and to local conditions at the work site; ensuring that all necessary FME requirements have been satisfied prior to authorizing opening of the affected system or component; monitoring periodically work task performance and work practices employed within the FMEA to ensure that plant FME requirements are upheld

Also, he has to assign a FMEM to monitor the FMEA as appropriate if the affected system or component, or other systems or components located within the FMEA, are

- (i) critical to personnel safety or station operations or
- (ii) will be left unattended for extended periods of time during work task performance

2.3 Work Group Supervisor

The work group (second line) supervisor will ensure that specified FME controls and procedures are applied, identifying deviations from planned controls, and approving such deviations; secure FMEM support (as necessary), and make sure that appropriate inspections are conducted by qualified personnel.

Also, Work Group Supervisor will ensure that appropriate corrective actions are taken as necessary, determine that emergent work receives the proper verification level by management walking around, and reinforce FME expectations and standards at work locations.

2.4 FME Monitor (FMEM)

The FME monitor is responsible for the following: understanding and ensuring that the requirements of an FMEA are implemented; controlling the FMEA when material or personnel control is established; maintaining and reconciling applicable logs; monitoring work activities; correcting FME problems; performing an accurate turnover to an oncoming shift FMEM; notifying the maintenance or work supervisory personnel about any unresolved problems.

2.5 Work Planner

The work or maintenance planner is responsible for the following: preparing work packages; performing field walk-downs; determining FME requirements; briefing the maintenance or work supervisor, and analyzing feedback to improve future work packages.

2.6 System Engineer

The system engineer's role is to ensure that appropriate FME requirements are specified on self authored work packages; approve any deviations from the FME requirements; determine that the tools and materials specified meet all regulatory and system design requirements, and to assist with

evaluation of material recovery techniques, their relative effectiveness, and potential adverse impacts on the system if FME controls are lost

2.7 Shift Superintendent

The shift superintendent is responsible for the reviewing and approving any deviations from the work package FME requirements and evaluating material recovery techniques, their effectiveness, and their impacts on system performance in the absence of the system engineer or second line supervisor.

2.8 Maintenance Manager and Maintenance Supervisors

The maintenance supervisor is responsible for implementing the FME program; administering the plant FME program and training; managing the FME guidelines; coordinating training and monitoring the quality of training; periodically visiting work locations to reinforce FME expectations and standards; investigating the root cause of FME incidents; conducting periodic work site observations to ensure that the maintenance organization and contractors are complying with the procedure.

Also, it is important to ensure that station and contractor personnel are trained in FME requirements.

3 IMPLEMENTING AND MANAGING A FME PROGRAM. WORK PLANNING AND PERFORMANCE

The keys to successful implementation of FME controls are recognition, understanding, and cooperation. Where workers recognize the need for FME controls, understand their responsibilities, act accordingly, and cooperate with one another while performing work tasks within an FMEA, successful FME control is easily achievable. The following general guidelines will aid workers, supervisors, and work planners to better recognize needs, understand responsibilities and cooperate with others during work task planning and performance.

3.1 Work Planning

Begin each planning activity by reviewing the work package requirements to determine the types of work tasks involved, identifying those tasks where FME control might be required. Perform a field inspection of the work site after reviewing the plant work control system. Note any local conditions, work in progress, or planned work activities that could raise an FME concern during performance of the activity in preparation.

In analyzing the potential FME requirements for a work task, begin by identifying the systems or components that must be opened or accessed in connection with work task performance.

Determine whether the work task area requires the posting of signage identifying FMEA boundaries or the installation of barriers that control or restrict personnel access.

If tools, parts, or other items used in work task performance are able to enter the system and might not easily be retrieved, consider implementing the following controls:

- Control materials allowed into the FMEA.
- Assign responsibility for tool and materials control.
- Document the use and removal of tools and materials.
- Do not allow the introduction of personal objects, for example, jewellery, change, pens, or other potentially loose objects, into the FMEA.
- Positively secure all required potentially loose objects, for example, gloves, badges, dosimeters, glasses, and hand tools, using tape, lanyards, or other appropriate devices. Ensure that these security devices do not, themselves, have the potential to become introduced into the system or component as foreign material.

Limit the access of unnecessary personnel to the FMEA. Provide for alternate routing of personnel engaged in other activities around the FMEA, and enforce the alternate route through the placement of an FMEM for the work task duration.

Evaluate the level of FMEA cleanliness required for performance of the work task. Pay particular attention to overhead areas and gratings. Ensure that all cleaning has been completed before beginning the work task and that all cleaning materials and cleaning residue have been removed from the area.

If system integrity must be breached and must also be left open (that is, the system left open) and unattended during work task performance, require that temporary covers be available for installation during those periods.

During activities involving open piping systems, specify the use of temporary pipe dams to reduce the possibility of FMI where practical, especially where activities such as grinding, valve lapping, or filing will take place.

In preparing the work package, be sure that a copy of the plant FME requirements covering the related work task is attached. Prominently note in the work package instructions that plant FME requirements information is included with the work package, and provide for a verification mechanism to ensure that those requirements have been located within the work package and reviewed by the responsible party before the work task begins.

3.2 Basic FME Work Practices

A practical knowledge and appreciation of where foreign material is commonly encountered during various types of plant operations and maintenance activities are important for avoiding FMI incidents.

At work task commencement, prior to actually opening a system or component, begin by establishing FMEA boundaries as required or applicable. Install boundary markers and remove non-essential materials from the FMEA and adjacent areas.

Clean the FMEA and adjacent areas using appropriate methods that are sufficient to provide the required level of pre-task cleanliness. Remember to inspect overhead gratings, walkways, railings, and other structures or components for dirt and other debris. Upon completion of this pre-activity cleaning, install a clean enclosure, as required, to facilitate FME for this work task. It is especially important to establish a clean work environment before beginning a work task. Thorough cleaning can be performed without the risk of creating an opportunity for FMI only before a system or component is opened.

After a system or component is opened for maintenance, one of the most effective ways to minimize the opportunity for FMI is to maintain a neat and clean work place by cleaning as you go—putting away tools after each use, removing any excess consumable materials and their containers immediately after use, and removing all cleaning materials used to maintain the work site after each use.

When preparing to perform a separate work task within a previously established FMEA, make certain that you coordinate with the work permit holder and/or first line supervisor so that no conflicts will occur that might jeopardize the maintenance of FME controls for either work task.

Cover all unattended openings into systems or components. Consider potential requirements for ventilation or ingress/egress when implementing opening covers. Use only plant-approved materials for covering systems and components.

When the use of an FME Log is in effect, log all personnel, tools, and materials in and out of the FMEA. Maintain both a daily FME Log for items not required for longer periods, as well as a long term FME Log to record items required within the FMEA on a continuing basis or until work task completion. Some plants also use a separate sheet in the daily FME Log for each worker entering the FMEA, to foster an element of increased accountability for items introduced into the area. Personal items, such as eyeglasses, earplugs, and dosimeters, are not normally recorded in the FME Log.

Secure all tools, materials, and equipment prior to introducing them into the FMEA through the use of lanyards or other acceptable means, as practical.

Make certain that all chemicals or chemical compounds introduced into the FMEA comply with plant guidelines and the plant chemical control program, if applicable. To the extent practical, do not keep trashcans or other general refuse containers within the FMEA. Collect and remove all dirt, debris, and other refuse as it accumulates. Remember to log out all trash, as applicable, in the appropriate FME Log.

Remove all personal items, for example, jewelry, contents of pockets, and other potential loose objects. Tape over clothing buttons, glove tops, and bootie tops to ensure that they do not become dislodged during work task performance. Secure eyeglasses, safety glasses, hard hats, hearing protectors, and other such items in such a fashion that they cannot become lost if they should be dislodged while worn within the FMEA. Some plants restrict the use of hard hats and earplugs over open pools and the reactor cavity.

As a rule, do not allow the use of transparent materials, such as visors or clear plastics, within an FMEA unless they are conspicuously marked to improve visibility and tracking.

When working within the FMEA, **ANTICIPATE!** Before initiating any task action, stop, think, act, and review. Expect the unexpected.

Use only fail-safe or tethered tools and materials and approved chemicals and solvents. Install pipe dams, opening covers, clean tents, or other specific barriers as appropriate. Inspect and clean the system or component internals as necessary immediately upon opening.

After the maintenance, repeat the inspection and cleaning before closing the system or component. Ensure that all materials used to inspect or clean the system or component are accounted for and removed from the FMEA immediately after use.

In the absence of an assigned FMEM, implement a two-person accounting process for tracking the introduction, use, and removal of all tools and materials used in the FMEA.

Introduce tools and materials into the FMEA only as they are necessary to support work task performance. Remove used tools and materials from the FMEA immediately after their use is completed.

Take special precautions to capture or control airborne foreign material when performing certain work tasks (for example, spray painting, sand/grit blasting, grinding, insulating, chemical cleaning, welding, cutting, and so on) that by their nature tend to generate foreign material as a by-product.

CAUTION: In activities that require grinding, drilling, sawing, machining, or lapping of valve seats, pay particular attention to the generation of loose material (grindings, filings, sawdust, etc.) that could be introduced into the area or nearby systems or components as foreign material. Experience has shown that vacuuming alone is not always sufficient to ensure material removal, especially in the case of lapping compound residue. Wipes, flushes, or similar methods must be used to be sure that all grit and debris are removed to prevent their intrusion into the area, system, or component.

Stellite debris from activities such as valve grinding or lapping are of particular concern because those particles can become highly radioactive after passing through the reactor. When grinding inside a system, make certain that all welding residue (for example, slag, grinding dust, and splatter) is carefully collected and removed. This includes residue from non-destructive weld examinations performed. Be sure to account for each unused welding rod and used rod stub that was introduced into the FMEA upon job completion.

Secure all sheets of paper, such as procedures, work packages, drawings, and signage, used in and around open systems and components. Include material and tool accounting within the Work Report or turnover process.

CAUTION: In the event that foreign material is introduced into the FMEA, system, or component, or if FME controls are lost, stop work immediately and notify the first line supervisor as well as the FMEM, if applicable. Do not attempt to recover foreign material from the system or component or to re-establish.

4 IDENTIFYING THE APPROPRIATE LEVEL OF FME CONTROLS

The appropriate level of required FME controls could be established by evaluating prospective work tasks and activities against standardized criteria.

4.1 FME Boundary Establishing

FMEAs can be divided into two or more importance levels to provide more effective administration of FME controls during work task performance. Cernavoda NPP uses three levels for establishing FME controls, as in the following table:

Table 1: FME Job Classification

Levels for FME controls	Description
FME Area LEVEL 1	The highest level of FME control imposed upon a system. Establish an Area 1 zone where final inspection of area cleanliness or immediate retrieval of foreign material is not possible.
FME Area LEVEL 2	An intermediate level of FME control imposed upon a system. Establish an Area 2 zone where an increased level of control is desirable because final inspection for cleanliness or immediate retrievability of foreign material might not be easily achievable.
FME Area LEVEL 3	The lowest level of FME control imposed upon a system. Establish an Area 3 zone where a routine level of control is desirable because final inspection for cleanliness and immediate retrievability of foreign material are easily achievable, and good housekeeping and work methods provide adequate controls.

The following decision tree, Figure 1, will aid in determining the appropriate level of FME controls required for a specific work task.

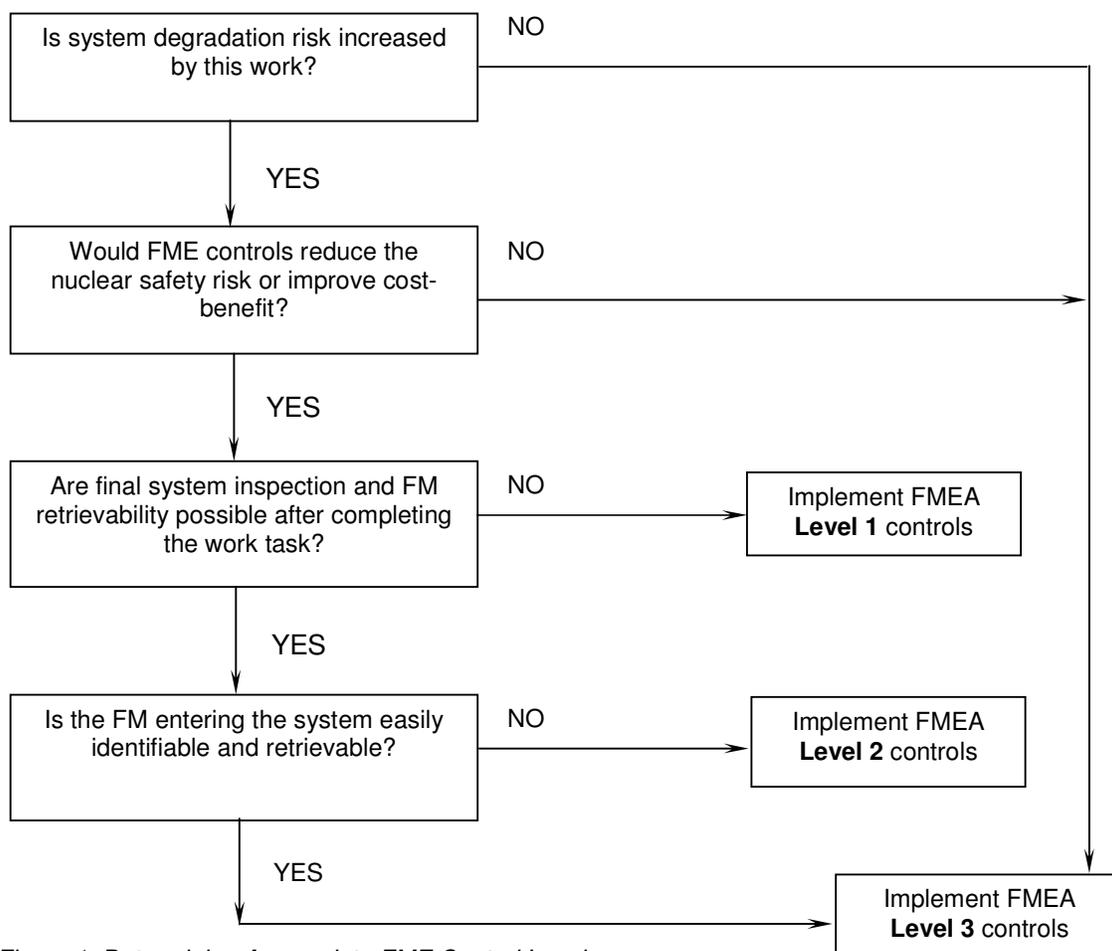


Figure 1: Determining Appropriate FME Control Levels

4.2 FME Job Classification Table

The following Table 2 provides additional considerations when you are establishing the level of FME protocols required for the performance of a given work task. These protocol requirements can include:

- Measures to be taken during work task performance to ensure FME
- Level of verification required for as-found and as-left inspections
- Tool and material requirements for FME

Where the work planner or supervisor in charge is uncertain of the proper classification used to establish work task FME requirements, consult with the system engineer for assistance in establishing them.

5 FME PROGRAM DEVELOPMENT

Several mechanisms exist to strengthen the FME program, including:

- **Personnel Training.** Personnel training is the cornerstone of an effective plant FME program. Consider ways to incorporate FME considerations into all operations and maintenance training programs offered to plant staff. Develop general FME training for all operations and maintenance staff as a part of your overall plant training program. Schedule focused FME refresher training ahead of the specific work task performance, as necessary. Make all plant staff, including management and administrative personnel, generally aware of the concept of FME control and its importance to successful plant operation.

- **Post-Incident Evaluation.** Post-incident discussions with involved personnel are one of the most effective ways to identify and prevent a recurrence of process-related FME incidents. Discuss each incident individually with involved personnel. Determine what happened from each person's perspective. Focus on why actions or decisions that led to the incident were made, and solicit suggestions for alternative actions or decisions that could be made to address similar circumstances in the future. Host a group discussion session to summarize and review individual suggestions for improvement, and develop a plan for implementation of those suggestions.

- **Leadership by Example.** Work task supervisors must take the initiative to ensure that they set a good example for craft personnel and others in thoughtfully considering and adhering to existing plant FME procedures.

Further, supervisors should also encourage others to take responsibility for considering potential FME implications associated with their work and to be aware of appropriate FME guidelines for particular plant maintenance activities.

Use insights suggested from plant personnel during routine training programs, and lessons learned from post-incident evaluations and from management observations during work task supervision and walk-around inspections of ongoing maintenance activities to provide feedback and improve aspects of the existing plant FME program as appropriate.

Table 2: FME Job Classification

Rating	Criteria	FME Requirements
Probability of Foreign Material Intrusion		
High	<ul style="list-style-type: none"> – Large openings sufficient to admit a person’s arm or use of hand tools. – Personnel entry or partial entry into the system or component. – Tools or inspection equipment will enter the system or component. – Foreign-material-generating activities. 	<ul style="list-style-type: none"> – Personnel entry or partial entry into the – FMEA boundaries are established with signage – FMEM(s) are assigned. – FME Log is in use. – All openings are sealed with temporary covers while unattended. – Special clothing is used. – Lanyards are used.
Moderate	<ul style="list-style-type: none"> – Medium to large openings. – Debris-generating activities. – Potential for foreign material intrusion from uncontrolled adjacent areas. 	<ul style="list-style-type: none"> – An FMEA is established. – Lanyards are used. – All openings are sealed with temporary covers while unattended.
Low	<ul style="list-style-type: none"> – Small openings. – No foreign-material-generating activities. – Clean work environment. 	<ul style="list-style-type: none"> – All openings are sealed with temporary covers while unattended. – Normal good work practices apply (see Section 6).
Difficulty of Foreign Material Detection		
High	<ul style="list-style-type: none"> – Foreign material might be difficult to visually detect from the work site. – Foreign material can migrate to a location with poor visual inspectability. – Foreign material might require special inspection equipment to detect. 	<ul style="list-style-type: none"> – Independent as-found and as-left inspections are performed. – Special inspection techniques are used, as required. – A post-maintenance flush is required, if possible.
Low	<ul style="list-style-type: none"> – All foreign material is readily visible. 	<ul style="list-style-type: none"> – As-found and as-left visual inspections are performed by workers.
Difficulty of Foreign Material Recovery		
High	<ul style="list-style-type: none"> – Foreign material cannot be readily recovered from the work site. – Foreign material recovery might necessitate opening other systems or components. – Special recovery tools or techniques might be required. – Lost foreign material could require or extend an outage or power derating. 	<ul style="list-style-type: none"> – Foreign material recovery plan is required as part of the work package. – Pipe dams and barriers are required to limit foreign material migration.
Low	<ul style="list-style-type: none"> – All foreign material can be readily recovered by workers. 	<ul style="list-style-type: none"> – Normal good work practices apply.

6 A CLOSE TO HOME EXAMPLE

An interesting example, which is more a technical accident than a FMI (Foreign Material Intrusion), happened during the 2003 planned maintenance outage at Cemavoda Unit #1, when an investigation into possible causes of steam generator feed water pipe vibration, specific to steam generator #2 were on going.

6.1 Introduction

The inspection was performed by lowering a video camera between the shell ID and shroud from the steam drum upper deck to view the thermal sleeve from above. During the inspection the Olympus PT 400 camera became lodged between the feed water box and the shell I.D. A second camera (Jamko) was deployed to view the Olympus camera. The Jamko camera also became stuck somewhere along the down comer when its removal was attempted.

As a result of the camera extraction effort that commenced on June 25, 2003, the B&W/AECL team was successful in removing the following:

1. The entire B&W "Jamko" camera & cable, which was lodged in the upper portion of the steam generator.
2. The entire length of camera cable that was originally attached to the SNN "Olympus" camera.

The "Olympus" camera body with associated cable strain relief (spirally wound spring) remained lodged between the feed water box tapered section and steam generator shell on the X-1 side of the feed water box. As a result of extraction efforts the camera cable became separated from the camera. The entire length of cable was retrieved. Numerous extraction efforts to remove the remaining camera body included the use of hooking devices and wire rope snare. Even when a considerable amount of downward/lateral force was exerted to dislodge the camera, no movement was observed. Any more aggressive attempts for extraction, at this time, would have presented unacceptable risk of introducing more foreign material into the steam generator. Therefore the extraction effort was discontinued.

The Camera components that remained in the steam generator presented minimal long-term risk to its operating integrity. The components were dispositioned to remain in the steam generator as per "Corrosion Consequences of Inspection Camera's left in Cemavoda 1 - Steam Generator 2", dated June 11, 2003. In its current location the lodged camera would have no effect on the operating integrity of the steam generator. If the camera became dislodged from the feed water box, the metallic components would fall to the top of tube sheet and come to rest in the annulus region around the tube bundle.

B&W/AECL recommended that secondary side inspection be performed in steam generator #2 to verify the position of the camera components, during the next scheduled maintenance shutdown and tooling prepared to extract the remaining camera components.

6.2 Camera Retrieval

The inspection and retrieval tooling was staged at the X-1 side of the steam generator. Both the 2 %" access port and 4" hand hole were opened. Three studs could not be removed from the 2 %" access port and one stud could not be removed from the 4" hand hole.

The equipment was set up on the X-1, 2 %" access port and the initial annulus inspection was started. The inspection was initially directed toward the cold leg side of the steam generator, as this would be the expected resting place of the camera if it fell from the feed water box above.

Once the inspection started the camera was immediately located behind the second shroud foot from the X-1, 2 %" access port (see figure 1). The camera was viewed from both behind the foot and around the side of the foot as shown in the pictures below.

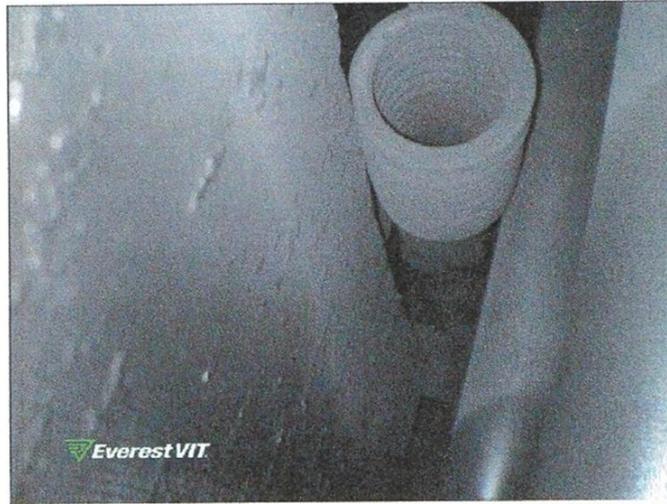


Figure 2: Camera was viewed around the side of the foot as shown in the picture.



Figure 3: Camera was viewed behind the foot as shown in the picture.

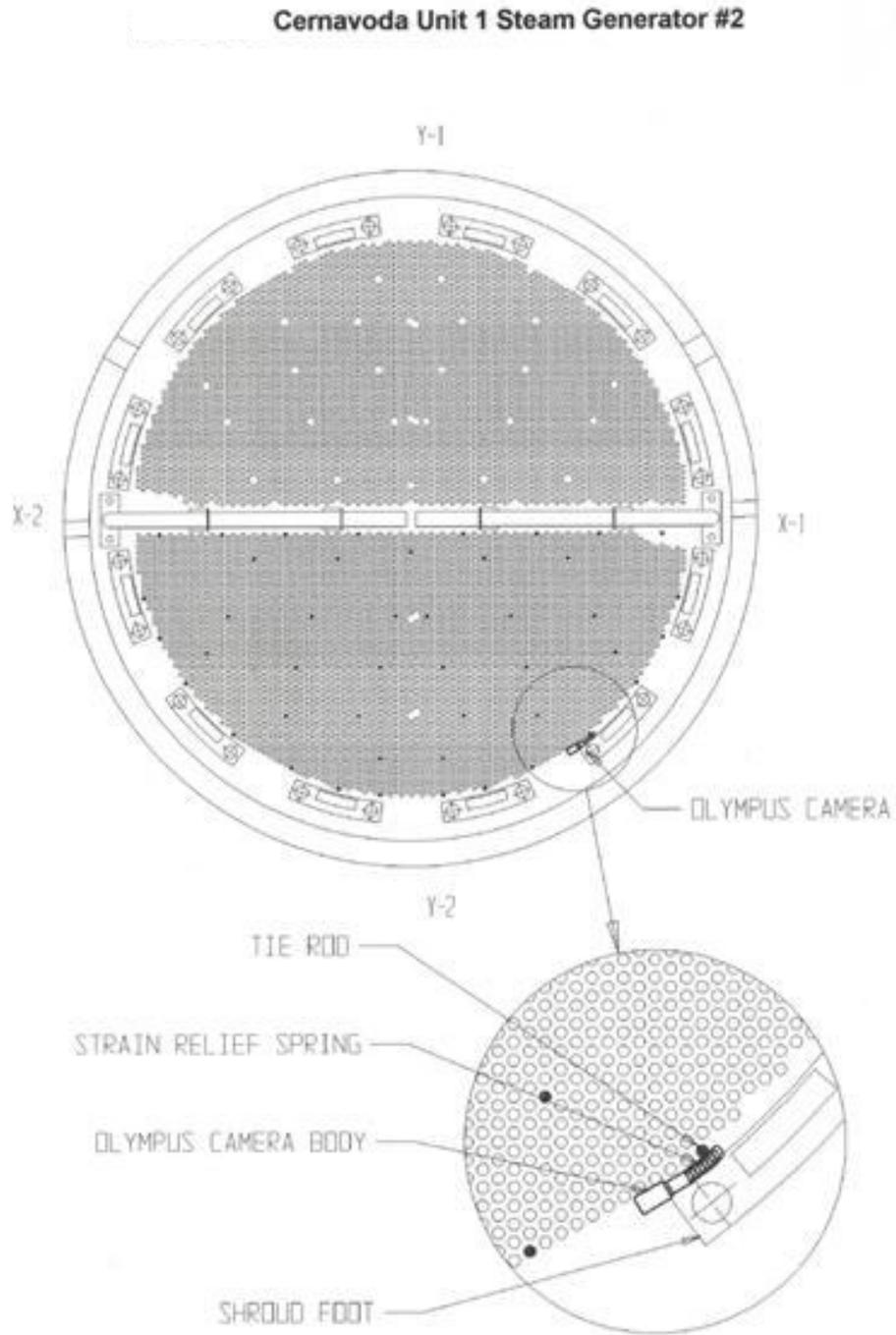


Figure 4: Camera location was confirmed close to X-1 port.

Once the location was confirmed, it was decided that the retrieval procedure that was most likely to succeed was to approach the camera from the 2 %" access port from the X-2 side. Although the camera was closer to the X-1 port, its location behind the shroud foot made a retrieval attempt from this side more difficult. Therefore, the X-2 access port was opened and the X-1, 4" hand hole was closed.

Once the camera was removed a complete annulus inspection was performed. This inspection confirmed that the annulus was free of foreign objects. The tubes in the area where the camera was retrieved from were viewed from several angles. Some scuffmarks on the tubes were visible however, no severe damage was apparent from this inspection. Some areas behind the shroud foot in the location of the spring could not be viewed.

6.3 Summary

As expected the camera was located on the tubesheet almost directly under its lodged location in 2003. All parts of the camera were retrieved. The camera once removed from the steam generator was compared to the parts list supplied by the manufacture. All the metal parts were intact. The only parts, which were not removed with the camera, were the plastic components that more than likely would have disintegrated under operating conditions. The final annulus inspection that confirmed that there were no foreign objects in the annulus supports this assumption.

The final annulus inspection showed that the tubes in the area of the camera did not appear to be severely damaged. Although a couple of tubes appeared to be scuffed, there was no visibly evidence of tube damage. The fact that the camera was easily retrieved from behind the shroud foot shows that the camera was not wedged in place. This coupled with the fact that ECT determined that the tubes in this area were not fretted, suggests that the camera caused no significant damage to the steam generator tubes.

7 CONCLUSIONS

To avoid equipment damage that could result in decreased system safety and reliability, system or component rework, and increased maintenance costs and radiation exposure the following should be strictly adhered to:

1. All staff is responsible for adhering to FME requirements. Foreign Material is material that is not part of the system or component as designed.
2. Control entry of material and personnel. Individuals should be free of loose dirt on clothing and boots and have no loose items in their pockets.
3. Ensure all openings are covered and check all systems and components before closing them up.
4. Prevent accidental entry of foreign material. Staff completes work in a timely manner to reduce the time that an open system or component is vulnerable to introduction of foreign material.
5. Recovering from an intrusion of foreign material. Notify the FLM of any problem in adhering to FME requirements.
6. Periodic monitoring and examination of work areas by the FLM assure adequacy of precautionary signs, tethering of tools, log keeping.
7. FME "as found/as left" inspections are mandatory and *MUST* be documented on the appropriate form and the work report.
8. Ensure all material removed upon exit. Re-establish system cleanliness prior to returning component to service. Poor housekeeping and FME practices in sensitive areas like Reactor Bays, Fuel Bays and around sumps can lead to damaged equipment and impaired safety.

REFERENCES

- [1] S.N.N.-S.A. "CNE-PROD" Cernavoda NPP Unit 1, Station Instruction SI-01365-P70 Rev.1, "Prevention of the Foreign Material Intrusion into the Plant Systems"
- [2] S.N.N.-S.A. "CNE-PROD" Cernavoda NPP Unit 1, Station Instruction SI-01365-P22 "Plant Housekeeping and Housecleaning"
- [3] Reid, Colin, "Steam Generator #2 Olympus Camera Retrieval at Cernavoda NPP Unit 1", Site Report to S.N.N. - S.A. "CNE-PROD" Cernavoda, September 16, 2004
- [4] EPRI TR-106756 Final Report, "Foreign Material Exclusion Guidelines", December 1997
- [5] INPO 92-001 "Maintenance Management Guidelines for Nuclear Power Plants "
- [6] INPO (SOER) 95-1 "Foreign Material Intrusion Event Reduction"
- [7] N-INS-09106-10001, Foreign Material Exclusion Planning
- [8] N-PROC-MA-0018, Foreign Material Exclusion