GEK110843G

GE Power

Cleanliness Requirements for Power Plant Installation, Commissioning, and Maintenance

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the GE Company.

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I. INTRODUCTION

A. Purpose and Scope

This document provides acceptable methodology and criteria for the project to define cleaning procedure.

To provide general rules and guidance for field activity and users regarding system cleanliness acceptance criteria for power plant installations, commissioning and maintenance. Cleanliness issues during manufacturing, installation, and commissioning can cause delays in delivery, performance degradation, and unit damage.

B. General

Technological advancements in the field of power generation have raised the level of importance for maintaining system cleanliness during all phases of manufacturing, installation and operation. Each improvement to efficiency and reduction in emissions require a further tightening in clearances and reduction in the margins for error. The level of cleanliness control which the new power plant installations demand, require a change in the approach to maintaining system cleanliness.

System cleanliness must be a plant lifetime approach ranging from inception to plant operations and maintenance. Strict, in-process controls to prevent contamination and to maintain the system cleanliness level are essential to the successful installation and long-term reliability.

The best practices learned during installations have decreased the average amount of time required to deliver a cleaner, more robust system. Applying these practices is important to obtaining expected performance and equipment life.

IMPORTANT:
Even if cleaning operation is planned, the system shall be maintained clean all along the project lifecycle (manufacturing, storage of equipment, installation, cleaning operation, commissioning and maintenance). Final cleaning operation may not allow complete removal of large debris, particles and rust contained into a system if the cleanliness process and preservation have not been properly implemented along the project life cycle

II. DEFINITIONS AND CONTROL

The purpose of performing a flush or air/steam blow is to remove foreign material from a system or component. Foreign material is defined as any material or object that should not be on or within the system hardware (Figure 1).

Figure 1. Metal Shavings found in piping following the Fitting Process

A. System Criticality Definitions

Cleanliness control levels will be defined in three categories: Critical, Controlled, and Foreign Material Exclusion (FME). If the system medium flows through components that can be considered to fall into more than one of these categories, the overall requirements for the entire system are categorized to the higher level of control.

Critical systems are defined as those systems where contamination of the system can cause a catastrophic failure. These systems require additional attention to ensure that system integrity is maintained.

Controlled systems are defined as those systems where contamination will cause degradation in unit or component performance or reduced component life.

Foreign Material Exclusion systems are defined as those connected to and have the potential to contaminate systems that are Critical or Controlled. Drain piping is an example of a foreign material exclusion system

B. Control of Foreign Material

To most efficient method of maintaining system cleanliness is to prevent entry of foreign material into system piping or components during installation and maintenance. The following steps should be observed to prevent entry of foreign material into Power Plant systems:

- Temporary covers or plugs (FME covers) shall be installed on all system piping, components, or tank connections opened for work or inspections, except during the time the opening must be uncovered to perform the evolution. This requirement also applies to material in staging and lay down areas.
- During storage phase, piping must be correctly stored, capped and protected against weather. GEK28156 shall be referred for preservation guidelines.
- FME covers shall be such that they cannot fit inside the system opening or have an installed capture device that guarantees their retrieval prior to component installation. The FME cover should cover the entire system opening. FME covers shall be constructed of a rigid, non-fibrous material. The use of wood, especially chip board or plywood, is not a recommended material as it

can splinter or shed and deposit material within the system. The use of rags or foam is also not a recommended practice (Figure 2 and Figure 3). The soft material may be pushed into a system opening thus becoming foreign material. Tape may be used to fasten the covers in place, but should not be used as a sole source of material exclusion.

- When the work is complete and prior to removal of the FME covers, inspect and thoroughly clean the work area to ensure that no foreign material is present. This includes the removal of loose or flaking rust and residue from grinding, chipping, welding, blasting, or other maintenance activities. It is important that FME devices be accounted for when system closeout is performed.
- Following fit-up of piping or installation of vital system components, a Quality Assurance or individual of supervisory authority should closeout and certify the cleanliness of that portion of the system.

Figure 2. 12” Piece of Foam Material used as an FME Cover, Removed from a Pipe Using Air Blows (Material was not detected during visual inspections)

Figure 3a. Examples of FME Covers utilizing Paper, Linen and Plastic Bags (Not a Recommended Practice)

C. In-Process Controls

A pareto of system contamination PAC case root causes show inadequate in-process controls to be a leading contributor. Understandably, it is necessary to remove FME covers to perform different maintenance and installation related evolutions. When the covers are removed, appropriate measures should be taken to prevent the introduction of foreign material as a result of the evolution.

All tools and maintenance related material and debris should be removed from the work area and be accounted for prior to replacing the FME cover on the system opening. This requirement would also apply to any material that is to be installed into a system. During maintenance evolutions, care should be taken to prevent foreign material from entering areas that are inaccessible for cleaning and visual inspections. Finally, visual inspections remain an excellent traditional manner of detecting foreign material. This is discussed later in the article.

D. Prohibited material and cleaning equipment

Steel wool, abrasive material, scotch brite materials are prohibited for use to clean the systems in direct connection to the machine,

Deburring tool shall be used to clean the tubes and piping.

E. Clean installation process

1. Material reception and storage

Inspect on site the piping raw material, the prefabricated piping and the equipment from factory: check cleanliness, internal surface state and caps (FME) are applied refer to 362A2412.

In case material cleanliness level is not satisfying, define a cleaning method according to piping pre-fabrication cleanliness guidelines defined in 362A2412.

2. Prefabrication

In case of raw material, prefabrication of the pipe spools on-site is beneficial by allowing pre-cleaning outside the final installation area. Keep working area clean and air blow during pre-fab using compressed air (dry, oil free and filtered air is mandatory). Cleanliness criteria shall meet according to 362A2412.

3. Installation

During installation on site, never leave the pipe open and always maintain the FME caps. When pipes are fitted, seal the gap with tape if not immediately welded. In case of pipe adjustment in situ (cutting & beveling), perform the operation away from the already installed piping when possible. If not, surrounding piping shall be protected. Those modified piping shall be air blown after adjustment and before final closing. Use vacuum cleaner to clean if necessary. Particular care shall be observed regarding welding dams for gas purging. Throughout installation process, perform regular piping internals inspection

4. System cleanliness check

Visual inspection of the welds, borescope is strongly recommended, if cleaning operation required, refer to 362A2412. Hold point (ITPL) shall be defined for inspection prior to each final weld fit-up. Visual inspection of the complete pipe internals with borescope is strongly recommended. Perform final air blow of complete piping system prior pressure test. Flushing hardware can be part of the blown system, can be used to discharge the dirt outside the system. After final installation, perform a

visual inspection and boroscopic inspection. If cleanliness criteria are not meet, please perform a cleaning operation according to 362A2412 until criteria is met. e. Pressure test the system according to the MLI 0204.

III. LUBRICATING/HYDRAULIC OIL FLUSHING AND ACCEPTANCE CRITERIA

Bearing lubricating oil, hydraulic, lift, seal and trip oil systems are considered as **Critical systems.**

Critical oil systems medium is to be maintained at NAS class 6 or better (refer to Table 1 and Table 2) with water content of <100 ppm (.01%). For sampling practice please refer to GEK32568. Besides NAS Class test, all critical oil system feed lines can be considered acceptable when each feed line individually passes two consecutive strainer mesh tests one hour apart. The following acceptance criteria shall be fulfilled for acceptance of clean screen test (100 mesh strainer).

- Use "naked eye" under normal lighting.
- No magnification or backlighting to be used.
- No hard particles (metallic, sand, etc.) are present in screen (hard particles in any size or any quantity are NOT acceptable).
- Small particles <300 microns that are soft (elastomeric) or crushable with fingernail are acceptable in quantities 3 or fewer per 1 hour flush.

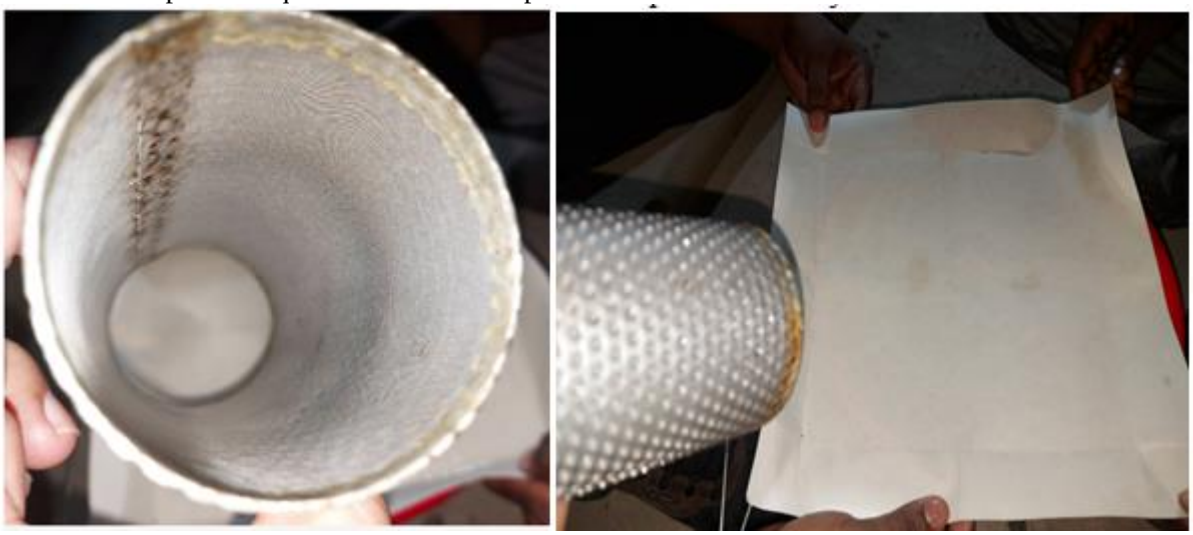

Figure 3b. Example of clean filter test

The 100 mesh bypass strainer may be inspected using ‘naked eye’ by cleaning the strainer in a spray bottle/clean bcuket with the solvent and flush this contaminated solvent in a coffee filter where the partcles can be easily visible using “naked eye” under normal light.

The following specific flushing procedures defines the detailed segment wise preliminary and phased flush sequences to attain required cleanliness level and these shall be referred based on unit configuration as applicable. When one of the following equipment/project specific flush procedure is applied to the project, these specific GEK’s/procedures shall take precedence over this GEK.

GEK121901**,** Flushing Recommendations, Lube oil system for STF (STEAM TURBINE FRAME) Steam Turbine with SPL (Structured Product Line) Generator
GEK116944, Flushing recommendations, Lube oil system with the units having feedlines inside the drain piping (Guarded piping).

MLI A125 Lube oil flushing instructions – Multi shaft GT & Generator.
For single shaft units, project specific lube oil system flushing procedure shall be referred.

A. General Guidelines on Flushing

Flushing must take place after piping installation, but prior to system operation. The success of an oil flush is dependent on: Success of efforts to keep contaminants out during storage, fabrication and assembly phases, and the proper conduct of the flush. Clean installation will lead to a successful flushing meeting acceptance criterion in a minimum of time with a minimum of effort.

Before starting cleaning operation, the system shall be prepared:

- All bearings and critical equipment shall be bypassed (bearings, Rexroth, float trap....)
- All opening inspected and cleaned. All piping sections that are not flushed must be inspected (Borescope/visual). All inspections shall be documented.
- Permanent Lube Oil skid is most often used for flushing and an external flushing skid may be used if it has same or higher flow capacity than permanent skid.
- LO skid preparation: Strainer installed upstream heat exchangers, filters cartridges installed, flow restriction as orifices shall be removed, pressure regulating valve fully open, lift oil pumps & block bypassed for initial flush.
- Tank shall be cleaned prior first filling, Oil to be filtered at tank first fill with a strainer mesh (β10=200) installed between the tank and tanker truck, oil characteristic shall be verified per GEK called on P&ID

Once system is ready, flushing operation can be started:

- Initial startup to test all lines for leakage, with end line strainer mesh removed (except SDE & BDE at initial start where meshes are installed to prevent contamination of BDE/SDE, piping between end line filters to BDE/SDE shall be inspected free of foreign object prior flush start).
- **Preliminary flush**: Flush all supply lines with max available flow (2 pumps intermittently) to maximize the flow in common supply and return lines to remove larger debris (with no mesh installed in flushing bypass except for GEN to protect BDE/SDE), after a certain period (depending on the configuration) flush the line by segment and record results (pumps amps VS number of lines flushed). Minimum duration 24 hours per bearing (of running operation/alternating every 3 to 5 hours). All along flushing operation oil temperature and flow rate shall be maintained as required high to ensure TURBULENT flow. Lift oil module (pumps and block) are bypassed for preliminary lift oil flush that is performed with lube oil pump)
- **Phased flush**: Flush each segment alternatively and separately, without strainer mesh installed, flow must be TURBULENT. During phased flush, lift oil pumps shall be used to ensure the max TURBULENT flow on each lift oil line and perform validation phases (Flush hardware shall withstand lift oil pressure and interlock of lift oil pump to run on LO feed pressure shall be active). Flush each lube, seal and lift oil feed line using lube oil pump and lift oil pump for 24 hours per flush sequence defined in the project specific flush procedure.
- Flushing records shall be maintained during entire flushing duration, NAS value per line at validation (date, time...), filter clean screen test validation (date, time, signed off by GE representative)
- Tank shall be drained, cleaned and inspected for cleanliness after flushing.
- System restoration, system reconfiguration shall be performed under FME. Specific check list to validate: cleanliness of all sections not flushed, ensure no contamination during reconfiguration, ensure all critical components are correctly re-installed per drawing (orifices, type of gasket, skid component, piping systems, system setting restored).

- All piping sections not included in the flushing operation must be hand cleaned and inspected. All openings shall be inspected. FME applied. All inspection must be documented. Including piping in the pedestals/bearings (when possible).
- Perform final inspection and check list sign off before final closing of each line
- No modification on the system shall occur after the flushing, in case of modification the system shall be re-flushed and cleanliness shall be validated.

B. Recommendations

Air Blows - In an effort to remove debris resulting from fabrication, storage, and installation, sites should perform air blows on system piping during the installation process. The piping should be blown down during initial fit-up and prior to final installation. The air used for the blows can either be instrument air or clean dry air from an off-base air compressor. After the pipe is installed, any open ends should be capped using a suitable FME cover. This procedure can be applied to nearly any system during the fit-up phase of installation as a useful precautionary measure. Figure 5 and Figure 6 show the effect of proper air blows on flushing effectiveness.

Flush velocity and oil temperature - For Lube oil and Seal oil, general rule is to maintain minimum flush velocity of 15 ft/s in each segment. In order to effectively flush small bore lift oil lines, turbulent flow based on pipe size as given in table 5 is required to flush lift oil lines. The lube oil shall be heated to 140°F - 170°F (60°C – 77°C) for both Preliminary and Phased flush. Temperature cycling is effective in dislodging particles. Temperature cycling of piping will inherently occur as part of the sequencing process from one segment to another as the isolated segment will cool and then reheat when next segment valved in.

Size	SCH	ID (IN)	Min Flow (GPM) required to achieve Turbulent Flow at 160F (Re > 4000)	Min Flow (GPM) required to achieve Turbulent Flow at 140F (Re > 4000)
NPS 2"	XXS	1,503	23,01	31,84
NPS 2"	160	1,687	25,83	35,74
NPS 1.5"	XXS	1,1	16,84	23,31
NPS 1.5"	160	1,338	20,49	28,35
NPS 1.25"	XXS	0,896	13,72	18,98
NPS 1.25"	160	1,16	17,76	24,58
NPS 1"	160	0,815	12,48	17,27
NPS 1"	80	0,957	14,65	20,28
NPS 3/4"	160	0,612	9,37	12,97
NPS 3/4"	80	0,742	11,36	15,72
NPS 1/2"	160	0,466	7,14	9,87
NPS 1/2"	80	0,546	8,36	11,57
NPS 3/8"	160	0,3	4,59	6,36
0.5" Tube	0.065 wall	0,37	5,67	7,84

Figure 3b. Turbulent flush flow rates

Vibrator - Vibrating and/or hammering the piping while circulating oil is very effective at loosening and dislodging scale, trapped particles, weld slag, splatter etc. and moving debris down drain lines. Pneumatic vibrators, provided by the installer, must be placed on all feed and drain piping. Mount directly to field welded joints. Plan for use of pneumatic vibrators or manual hammering with wood or plastic hammers on both supply and return lines during flush. Assure size of pneumatic vibrator is appropriate especially for smaller feed lines. Operate vibrators and perform hammering during both Preliminary and Phased flush operations. Plan and track application of vibrators and hammering with a map or log.

Figure 4. Pneumatic Vibrator

Maintenance Practices - Cleanliness controls in maintenance practices are critical in preventing system contamination. The use of FME covers on system/pipe openings, good housekeeping/clean work areas (free of debris from related or non-related work) and visual inspections cannot be overstated.

Visual Inspections - Visual inspections are essential to ensuring that foreign material is not introduced into or left in the system. All piping and system openings should be inspected prior to final installation/closeout.

CAUTION

Temporary filter mesh or basket shall not be installed in drain line to avoid risk of clogging, overflowing-flooding upstream of the mesh.

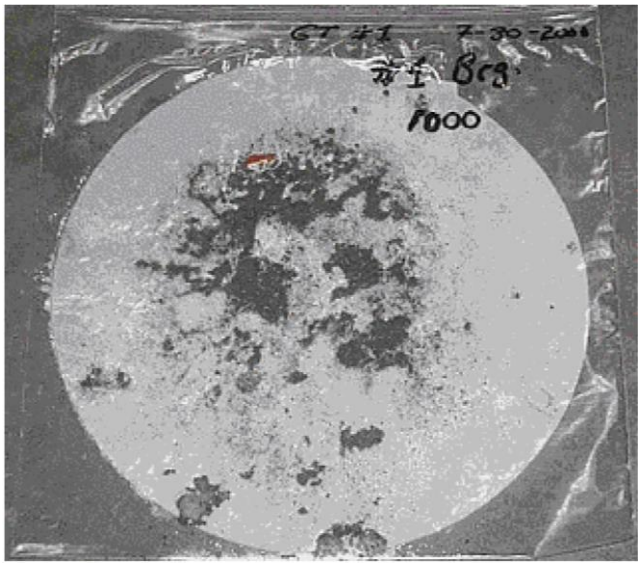

Figure 5. Initial #1 Bearing Flush Results from Lube Oil Piping without Air Blow. Flushes required 18 days

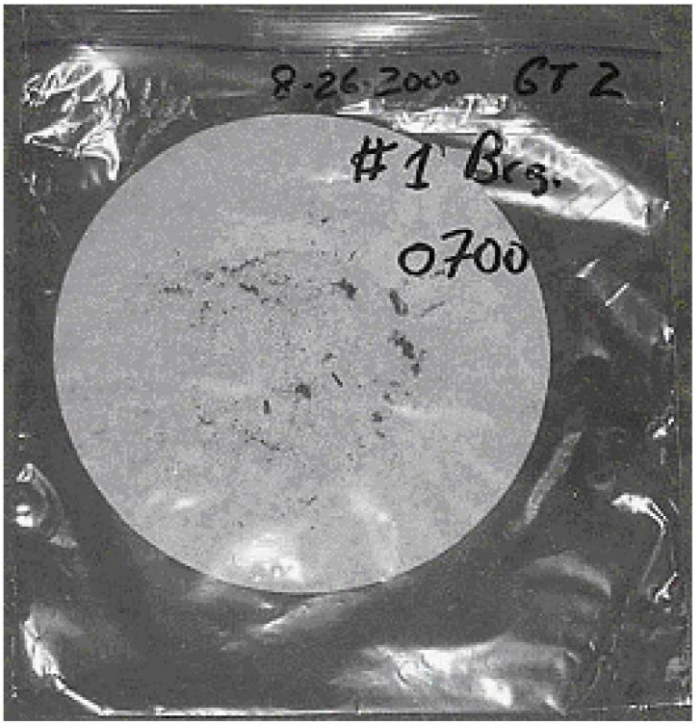

Figure 6. Initial #1 Bearing Flush Results from Lube Oil Piping after Air Blow. Flushes required 10 days

Figure 7. Y-strainer

C. Contamination Measuring Technique

Sites should use the following guidelines to measure flush performance and system cleanliness:

WARNING

A CUP OF BRAKE SOLVENT CAN DESTROY THE CHEMICAL PROPERTIES OF A 3000 GAL OIL SUMP. CARE MUST BE TAKEN TO ENSURE THAT ELEMENTS ARE CONTAMINATE FREE WHEN RETURNED TO THE SYSTEM.

- NAS SAMPLING: For sampling practice please refer to GEK32568
- At the conclusion of a successful whole system flush, if the flush oil is removed the tank must be cleaned with lint free rags. Use of a truck as storage or source of replenishment fluid should be scrutinized closely. A typical sample of replacement fluid from a truck yields a contamination level of NAS class 10. This is a common source of post-flush contamination. When feasible, replenishment fluid should be polished prior to introduction into the system. It is the responsibility of the installer to ensure that proper filtration, on the order of $\beta_{10} = 200$, is installed between the tanker truck and the oil reservoir to ensure the installed oil meets a minimum cleanliness level. Although, the practice of reusing oil is strongly discouraged by engineering, it is recognized that this practice is occasionally utilized in the field. In the event that the site personnel, end user, and oil vendor all concur that reusing oil is acceptable, it shall not be done without reconditioning. Reconditioned oil shall meet the requirements of the applicable **GEK's by full spectrum oil analysis** by the Original Equipment Manufacturer (OEM) of the lubricant or a qualified third party.
- After the operating oil is charged back into the system, oil analysis should be performed. The quality of the oil shall meet the requirements defined in the appropriate GE specifications.
- Fill oil must be verified to meet cleanliness specifications of the system. Sampling and analysis should be performed at the beginning, middle and end of an oil transfer to verify cleanliness level. Typical refresh oil is several NAS classes less than required.

Verifying and maintaining a clean oil system will help to ensure proper operation and help attain maximum performance of the system and components.

Table 1. Cleanliness Level Particle Count

NAS 1638 (1964)	Based on 100 ml sample				
	5-15 micron	15-25 micron	25-50 micron	50-100 micron	>100 micron
12	1,024k	182k	32,400	5,760	1,024
11	512k	91,200	16,200	2,880	512
10	256k	45,600	8,100	1,440	256
9	128k	22,800	4,050	720	128
8	64,000	11,400	2,025	360	64
7	32,000	5,700	1,012	180	32
6	16,000	2,850	506	90	16
5	8,000	1,425	253	45	8
4	4,000	712	126	22	4
3	2,000	356	63	11	2
2	1,000	178	32	6	1
1	500	89	16	3	1

Table 2. NAS versus ISO

NAS	12	11	10	9	8
ISO	23/21/18	22/20/17	21/19/16	20/18/15	19/17/14
NAS	7	6	5	4	3
ISO	18/16/13	17/15/12	16/14/11	15/13/10	14/12/9

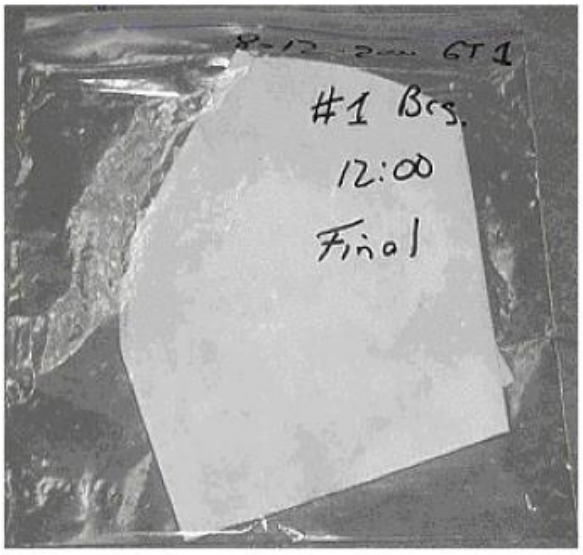

Figure 8. Visually Acceptable Filter Sample Unrelated to NAS Class

IV. LIQUID FUEL OIL FLUSHING AND ACCEPTANCE CRITERIA

Liquid Fuel Oil systems are controlled systems.

Controlled fuel oil system fluids are to be maintained at an NAS class 10 specification (refer to Table 1 and Table 2) with water content of <0.1 vol. %.

Drain piping is an example of a foreign material exclusion system.

Foreign Material Exclusion fuel oil systems are to be maintained free of debris and water.

A. Contamination Measuring Technique

Sites should use the following guidelines to measure flush performance and system cleanliness:

- Remove the filter element from the system and place on a clean coffee filter or lint free rag. The coffee filter/lint free rag will provide an area for sample collection and inspection.
- The sample should be free of visual contamination and debris for an acceptable level of cleanliness. Two acceptable samples obtained at least two hours apart, are required to verify the cleanliness of the system or portion of the system that is being flushed (Figure 9).

Figure 9. Acceptable Filter Sample - Unrelated to NAS Class

- If normal system fuel oil is used for the flush, the fuel oil may be pumped back to the holding tanks during the course of the flush to be used for subsequent system operation.

Verifying and maintaining a clean fuel oil system will help to ensure proper operation and help attain maximum performance of the system and components.

V. GAS FUEL SYSTEM CLEANLINESS AND ACCEPTANCE CRITERIA

A. General cleaning information

Verifying and maintaining a clean fuel system will help to ensure proper operation and gain maximum performance of the system and components. Level of cleanliness for customer's equipment scope of supply shall meet cleanliness requirements defined in 362A2412

Gas Fuel system is divided into 3 sections to facilitate the interpretation of this summary instruction. Please consider the following sections as independent systems:

Section-1: **GT On-base system**: from Gas Fuel control Module (FG1) up to GT combustion chambers - CRITICAL system

Section-2: **GT Off-base system**: from GE off base module absolute separator/Scrubber up to GT Gas Fuel Control Module (FG1) including interconnection piping - CONTROLLED system

Section-3: **Gas Fuel Plant system**: Customer supply line to the GRS (Gas Receiving Station), GRS & interconnect piping up to GE GT off base module absolute separator/Scrubber - CONTROLLED system

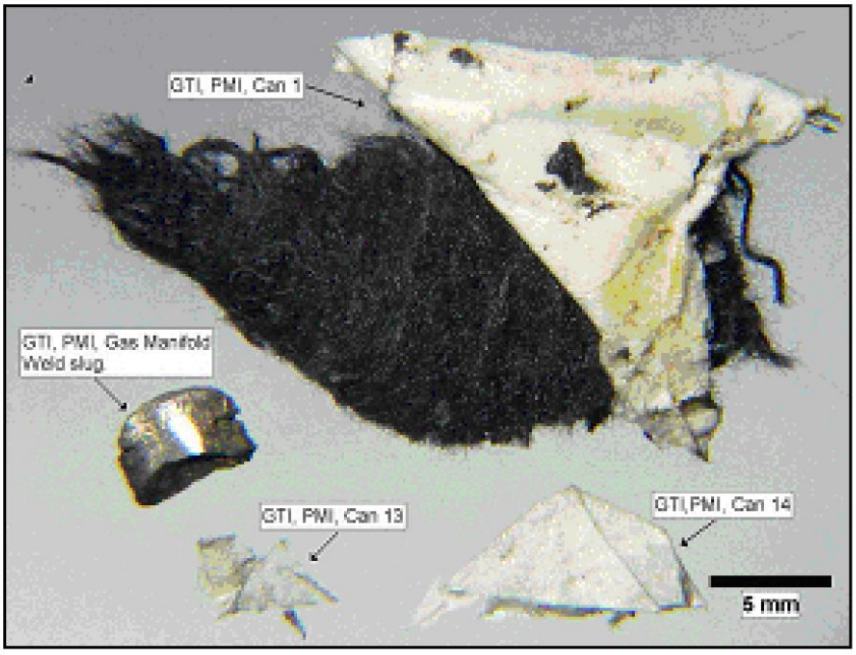

Figure 10. Example Contaminants found in Gas Piping

B. Section-1: GT On-Base system

The following specific cleaning instruction is applicable for On-Base system. 302T5805, Cleaning Instructions, All GT frames – Gas Fuel System cleaning.

SCOPE: GT Gas Fuel ON base piping (MLI 0422): GT ON base From GT Gas Fuel control Module (FG1) up to GT combustion chambers

GT ON base piping is separated into 3 categories; depending on the configuration the cleaning methodology can vary:

- Category 1: The GT on base piping & gas fuel control module are installed from Factory on the turbine & auxiliary base, piping is already cleaned from factory, no further cleaning required except inspection at Turbine & auxiliary base terminal point during installation.
- Category 2: GT with Gas fuel on base piping already installed & cleaned from factory: Perform borescope inspection at GT enclosure and gas module terminal points, hand clean/air blow separately and inspect/GE witness the installation of the gas fuel piping interconnect spool between Gas Fuel control valve module & GT package terminal points including the purge air interconnect piping.
- Category 3: GT with Gas fuel on base piping not installed from factory (site installation of gas manifold & pigtails)

1. Cleaning methodology for the Category 3 where air blowing is required up to combustion cans

See below detailed cleaning methodology for GT with Gas fuel on base piping not installed from factory:

PREREQUISITES: Air reservoir is required and shall be cleaned prior admitting air to GT on base system.
The air purge on base piping is cleaned separately during installation:
With AM module:

- Inspect all openings of the AM modules to confirm cleanliness
- Blow the prefabricated spools between AM modules and turbines (during installation phase), install clean 100% inspected

Without AM module:

- Blow each of the prefabricated spool (during installation phase), install clean 100% inspected
- Then as an option, this clean turbine piping system can be used as reservoir to clean other systems (ideally when system is under pressure test configuration with blind flanges installed).

If GT gas fuel Off base skids system is used as reservoir to clean the On-base part, it shall be cleaned prior to cleaning the GT On base system.

The whole system starting from the first GE GT conditioning area skid (absolute separator or Scrubber) up to FG1 is charged with dry & oil free air at 6 to 7 bar and is generally used as air reservoir to blow the GT On base system.

When required for early completion of the GT On base piping & GT compartment (to avoid waiting on GT Off base modules system to be completed), an external reservoir or the GT Cooling & Sealing piping can be used as reservoir to blow out the GT ON base Gas Fuel piping through the purge valves and/or connected at FG1 through the gas stop & control valves. This option is particularly interesting in case of non-modularized dual fuel configuration as other systems can also be air blown during construction (Atomizing Air/Water Injection/Water Injection purge/Liquid Fuel purge, Water Wash, self-cleaning of air filter), this concept requires special tool kit to be designed/procured and anticipated in advance by the constructor.

CLEANING PROCESS:

- Air blow the gas fuel piping up to the GT combustion cans including pigtails disconnected from combustion cans with all last chance strainers installed (inspect and clean the strainer after the blow prior start-up). Typical expectation: at least a minimum of three blows per group of flex hoses with a discharge time of more than 15 seconds. Adjust the number of opened pigtails according to the air blow duration and reservoir capacity. Cleaning of the system shall be continued up to verifying the cleanliness of the last chance strainers.

- Pigtails need to be secured tight during blowing to prevent any damages & FME covers are placed on the exposed combustion end-cover openings.
- Prior to performing the blows, the piping system should be air pressure tested for leaks.
- First blow of each manifold is performed using the pigtails at the bottom of the manifold to extract any debris
- Part of the purge system can also be air blow from the gas fuel control module up to an appropriate disconnecting spool piece.
- To perform this blowing the gas purge valves, SOV, stop valves, control valves, vent valves will have to be actuated. Depending on the unit this may require instrument air, hydraulic oil or electrical power supply, in addition the MKVI control & interconnect cables are required to control the actuators. If blows are performed during construction period with an external air reservoir the control of the actuators can be perform with temporary means (injection sources).
- During pressurization of the system take the opportunity to leak & live check all the system up to GCV's including instrumentation and potentially internal leaks of shutoff, Stop & Control Valves.
- Once a gas manifold is completed, the pigtails and end-covers should be inspected and re-connected immediately prior to moving to the subsequent manifold to prevent further contamination.
- 100 % borescopic inspection of all the pigtails and piping is required after air blowing.
- Following the blows the flanges should be inspected and either connected to downstream piping or covered with temporary FME covers.

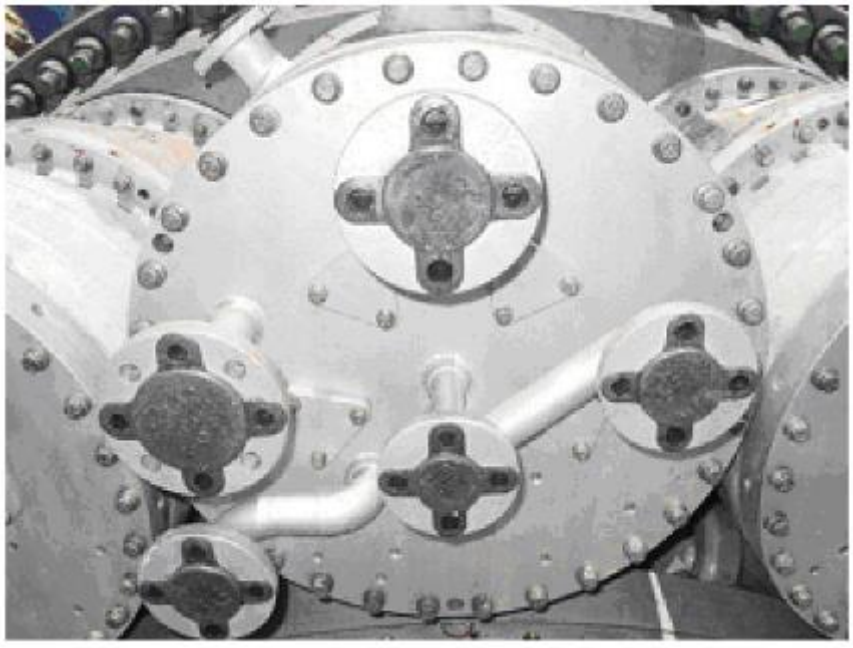

Figure 11. FME Covers On A Combustion Can End-Cover

2. Cleanliness criteria

- Air blow duration: 15 seconds x 3 times (Minimum).
- Last chance strainers to be checked → free of debris after air blowing.
- 100 % borescopic inspection of all the pigtails and piping downstream last chance strainer after air blowing

- For sections 1, cleaning procedure shall be submitted to GE project team during construction phase. Cleaning results and evidence of clean installation shall be documented and shared with the GE project team and use to confirm cleanliness at the Red Flag Review.

C. Section-2: GT Off-Base system

The following specific cleaning instruction is applicable for GT off Base system. 302T5805, Cleaning Instructions, All GT frames – Gas Fuel System cleaning.

SCOPE: GT Gas Fuel Off Base Modules (MLI 0482): from GE off base module absolute separator /Scrubber up to GT Gas Fuel control Module (FG1) including interconnect piping

1. Cleaning methodology

PREREQUISITES: during engineering phase, ensure air blowing spool pieces according to cleaning concept are installed at strategic locations versus pipe layout and verify pipe routing/distance between skid (before FG1, before each GT off base skids if line upstream is long, downstream & upstream GT off base skids if pigging process is used).

CLEANING PROCESS:

- Perform visual or borescopic inspection on the GT Off base GE skids to check modules cleanliness requirement, open and hand clean if needed.
- Check the off-base interconnect piping for internal piping cleanliness (Carbon Steel & Stainless Steel). If internal piping surface present stuck deposit that cannot be removed by air blowing (muds, sand or metal chips stuck to the pipe surface accumulated during storage/installation or due to poor prefabrication process) clean the piping with high pressure water jetting, drain and dry with air blow immediately after.
- During installation hand clean & inspect the interconnect spool < 10 meters piping length and document the inspection, lines below 4" will be clean by continuous air blow process.
- For interconnect spool between GT Off base modules > 10 meters piping length that cannot not be installed clean, they shall be air blown separately, perform air blowing using GT off base module as reservoir upstream the piping to be clean and install air blow out valve or rupture disk at the discharge of the piping section to be cleaned prior the next GT off base module (GT Off base modules cannot be use to pass air flow if line upstream have not already been cleaned). When using Gas absolute separator as an air reservoir the filters cartridges can be left in place, but the valves upstream shall be closed to not exceed the velocity limit of the filters. The temporary strainers on the GT off base skids shall remain in place during air blow. Flowmeters can also remain in place if upstream part is cleaned (flow conditioner & orifices shall be removed during air blow operation).
- Air blow the interconnect piping using Off base GE skids as a reservoir up to gas fuel control module inlet FG1 (typically 6 to 8" blow valve). SSOV is replaced by a spool or spacer if within the air blow circuit and in some cases the air blow exhaust can be install in place of SSOV if last spool to FG1 is short (if line upstream SSOV is already blown and clean then the SSOV can remain in place in open position within the air reservoir for the air blow process). The whole system starting from GT gas absolute separator or gas scrubber up to FG1 is charged with dry & oil free air at 7 to 8 bar and discharged with blow out valve at FG1. During the first air blows, if bypass of the performance and startup heaters are available they shall be opened and then closed for the next blow. The air blow-out must be repeated at least 3 times or until cleanliness requirements are met. A clear air blow plume shall be visually seen, or a target can be used to monitor blowing from first to last blow: soft material such as brass or aluminum plate installed on the pipe exhaust.

- Limitation: In case of long interconnect piping length, intermediate spool for air blow might be required to clean the line by section. During engineering phase simulate the velocities versus system volume, line length and discharge valve diameter with objective to maintain velocity from 30 to 60m/sec during the blow on the entire piping length, those velocity are commonly maintained for 5 to 8 sec during each blow.
- Air blows should be done in the direction of flow for the GT gas fuel off base system to avoid to blow backwards through GE equipment as none of the equipement is designed for the reverse flow.

Preserve the modules and Carbon Steel lines immediately after cleaning.

2. Cleanliness criteria

- If interconnect piping present stuck deposit as muds, sand, or metal chips it shall be mechanically cleaned prior to air blowing
- The air blow-out must be repeated at least 5 times or until cleanliness requirements are met with clear air blow plume
- 30 to 60m/sec during the blow on the entire piping length, those velocity are commonly maintained from 5 to 8 sec
- For sections 2, cleaning procedure shall be submitted to GE project team during design phase. Cleaning results and evidence of clean installation shall be documented and shared with the GE project team and use to confirm cleanliness at the Red Flag Review.

D. Section-3: Gas Fuel plant supply system

- The GEK116771 is applicable for the gas fuel plant supply system cleaning.
- GEK116771, Cleaning Recommendation, All GT frames – Fuel Supply System Cleaning for Gas Turbines.
- SCOPE: Gas Fuel Plant Supply system is composed of 3 subsections:
- SubSection-1: Customer supply line to the gas receiving station.
- SubSection-2: Gas receiving station
- SubSection-3: Interconnect piping from gas receiving station to GT off base modules (Gas absolute separator /Scrubber)

1. Cleaning methodology

Cleaning methodology will vary according to the piping section and configuration:

Subsection-1: Pigging (hard pig 2 pass minimum + soft pig 3 pass minimum and no more debris collected), pigging is always followed by quick decompression air blowing (full bore quick decompression at least 3 times or until cleanliness requirements are met)

Subsection-2: Piping spools are mechanically cleaned after prefabrication and capped, installed clean, spools are air blown as required and 100% inspected during installation. In case of long spools not arriving clean to site, other mechanical cleaning alternatives such as high-pressure water jetting followed by air blow-out should be used. If overall gas receiving station cleanliness cannot be confirmed cleaned install per above, it shall be part of the main section 3 air blowing (bypassing critical component like pressure regulation, metering.....). Often the Gas receiving station is used as air reservoir to air blow the downstream interconnect piping (section 3).

Subsection-3: Interconnect piping is recommended to be pigged (refer to section 1). If this is not possible, high pressure water jet is recommended. After pigging or high-pressure water jetting, quick

decompression air blowing should be conducted (Section-2 can be used as a reservoir), typically 8 to 10" blow valve at least blown 3 times or until cleanliness requirements are met. Pig receiver and air blow exhaust shall be located just upstream GT gas absolute separator /scrubber. In some cases of high piping contamination or contract requirement this line can also be cleaned by chemical cleaning followed by quick decompression air blowing.

2. Cleanliness criteria

Gas fuel quality & gas network pretreatment systems are required to be designed by the Customer in accordance with GEI41040. For sub sections 1, 2 & 3: Cleaning procedures shall be submitted to GE project team during design phase. Cleaning results and evidence of clean installation shall be documented and shared with the GE project team and use to confirm cleanliness at the Red Flag Review.

The gas fuel should be analyzed with sample to ensure GEI41040 specifications are met.

Air blows: Cleanliness verification through visual observation of clean air plume, or service target blow evolution: brass or aluminum target installed on pipe exhaust. Required CFR (>=1.2) should be achieved. Visual inspection of low points, dead ends, and increases in pipe diameter to be verified during reconfiguration.

Pigging: Pigging process shall follow pig supplier instructions, minimum 2 runs with hard pig, 3 runs with soft pig followed by quick air blow decompression or until cleanliness requirements are met.

Maintenance Practices - Cleanliness controls in maintenance practices for fuel gas system are critical in preventing system contamination. The use of FME covers on system/pipe openings, good housekeeping/clean work areas (free of debris from related or non-related work) and visual inspections cannot be overstated.
Visual Inspections - Visual inspections are essential to ensuring that foreign material is not introduced into or left in the system. All piping and system openings should be inspected prior to final installation/closeout.

VI. AIR SYSTEM CLEANLINESS AND ACCEPTANCE CRITERIA

All air systems; excluding service or shop air are controlled systems.
Service/shop air systems are foreign material exclusion systems.
The blowdown of air systems should be conducted.

A. Contamination Measuring Technique

Sites should use the following guidelines to measure and verify system cleanliness:

- During the performance of an air blow to either establish or verify cleanliness, a 100-mesh strainer (140 μm) should be placed in the discharge path to collect any debris from the piping or system.
- The sample should be free of visual contamination and debris for an acceptable level of cleanliness. Two consecutive acceptable samples are required to verify the cleanliness of the system or portion of the system that is being air blown.

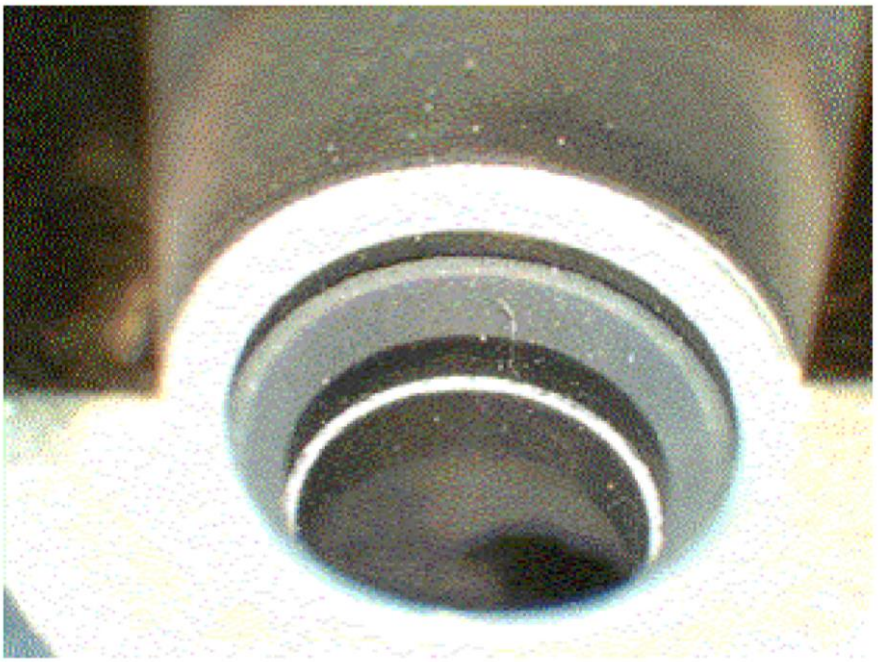

Figure 12. Fine Contamination causing a purge check valve to fail

B. Recommendations

Air Blows - In an effort to remove debris resulting from fabrication, storage, and installation, sites should perform air blows on system piping during the installation process. The piping should be blown down during initial fit-up and prior to final installation. The air used for the blows can either be instrument air or clean dry air from an off-base air compressor. After the pipe is installed, any open ends should be capped using a suitable foreign material exclusion (FME) cover.

The air blows will significantly reduce the amount of debris in the piping. Air blows have proven successful in removing debris when using a 200-gallon receiver charged to 100-125 psig and discharged through a two-inch hose. The blow should last between 5-10 seconds and should be repeated 4-5 times unless cleanliness levels dictate that more blows should be performed. The size of the hose used for the blows should be such that the hose is able to fit into the pipe opening and still allow the maximum flow rate possible. For example, a two-inch hose used to blow a six-inch pipe proved to be successful.

Maintenance Practices - Cleanliness controls in maintenance practices are critical in preventing system contamination. The use of FME covers on system/pipe openings, good housekeeping/clean work areas (free of debris from related or non-related work) and visual inspections will reduce the possibility of introducing foreign material or debris into a piping system.

Visual Inspections - Visual inspections are key to ensuring that foreign material is not introduced or left in the system. All piping and system openings should be inspected prior to final installation/closeout. Inspections should be performed using a flashlight and a mirror where practical and a borescope if required. A visual inspection, with no contamination visual to the naked eye, is sufficient to call an air system “clean”.

Obtaining a smear of a dry area of piping near an exit and comparing the smear sample to the examples in paragraph 10 of reference 1 is an option to further confirm the cleanliness of air systems.

This is not required but represents another opportunity to verify system cleanliness. Table 2 of reference 1 provides recommended contamination levels in mg/m2 for air systems.

Verifying and maintaining a clean air system will help to ensure proper operation and gain maximum performance of the system and components.

VII. STEAM PIPING CLEANING AND ACCEPTANCE CRITERIA

Steam Supply and Steam Seal systems are controlled systems.

Experience has shown the importance of thoroughly cleaning the main steam, reheat steam, and steam seal systems prior to turbine operation or after the completion of a new installation or major repair work to the steam system. Debris left in the system would otherwise be blown into the turbine and cause serious damage to the steam path parts. The temporary fine mesh screens installed on the main stop and combined reheat valves during initial startup are not intended to be a substitute for cleaning the steam lines.

The objective of a chemical cleaning and air or steam blowdown is to minimize the possibility of damage to the turbine by removing pipe scale and other foreign material, which might otherwise be carried over into the machine.

The following equipment and steam piping should be chemically cleaned and air blown or steam blown prior to undertaking plant startup testing.

1. Each heat recovery steam generator and its steam lines.
2. The main steam lines and header from each heat recovery steam generator through to the turbine bypass piping just upstream of the turbine bypass desuperheater valve. The turbine bypass desuperheater valve must not be in the steam path during blowdown. The Purchaser shall supply temporary piping including a blowdown valve to be connected at a point just upstream of the turbine bypass desuperheater valve.
3. The main steam lines and header through to the turbine stop valve(s).
4. The steam seal piping can either be acid cleaned, service steam blown or shot blasted & installed clean. In case of shot blasting it shall be done with steel bullets and not with sand.

A. General Guidelines on Chemical Cleaning of Steam System Piping

Chemical cleaning of the piping upstream of the main stop valve or combined reheat valve will require the installation of special chemical cleaning hardware to protect the turbine and valve internal parts. General Electric can supply the hardware as extra cost items when required.

The acids or caustics used during chemical cleaning attack certain materials commonly used in these turbine assemblies and must be protected. Hydrostatic tests should be completed prior to the installation of the chemical cleaning fixture(s). The chemical fixture may collapse if installed during the hydrostatic tests. The fixture should be installed during the blowdown in order to prevent foreign matter from depositing adjacent to the valve seat and plug.

B. Chemical Cleaning Process

The chemical cleaning method shall be in line with known international standards. Special care has to be taken that the chemicals used will not harm the systems, especially when special alloy material is present.

Flushing: Objective is to remove big debris, particles, sand, mud…

The system is flushed with demineralized water at velocities as defined by VGB guideline. Intermediate extraction temporary piping shall be added on re-heater, super heater low points CCC (Chemical Cleaning Connections) and if applicable in once through HP Economizers to ensure debris extraction at low points during flushing process and during process draining steps. Flushing can be performed in open loop configuration or in close loop configuration using full flow redundant strainers to ensure debris removal.

Hot degreasing: Objective is to degrease surfaces

After reaching cleanliness criteria of the previous step the systems filled with demineralized water are homogeneously heated until the operative temperatures planned for the cleaning are reached. The required reagents for the degreasing step are added and the solution recirculated until the following criteria have been reached:

- The solution has reached the required operative temperature (usually around 65 to70°C) at the coldest spot of the circuit and has circulated for at least 4h at this temperature
- The absence of oil is confirmed with 3 consecutive samples during the recirculation

Acid cleaning: Objective is to remove mill scale, corrosion products and soluble impurities

Without draining the system the chemical agents (typically inhibited citric acid or hydrofluoric acid) are injected and circulated. For the selection of the optimum agent local regulations and laws related to use and disposal of chemicals and resulting effluents need to be considered. During the entire process the temperature shall be maintained above the required operative temperature (usually > 65 to 70°C) at the coldest point of the circuit. The acid cleaning might be followed by a stabilization step where the corrosivity of the acid phase is gradually reduced by change of pH, concentration of acid or redox potential. After the acid cleaning and / or stabilization step the high concentrated solutions shall be drained completely under N2 atmosphere (except if single volume cleaning is applied).

Rinsing: Objective is to remove left overs of the high concentrated chemical solutions of the previous steps

The system is flushed with demineralized water until the cleanliness criteria are reached. Depending on process the pH of the rinsing water might be adjusted to > 9 by the addition of ammonia.

Passivation: Objective is to form a protective oxide layer on the cleaned surfaces

Passivation agent is added to the solution and circulated to passivate internal surfaces. In order to limit risks of residual chemicals during operation the use of volatile chemicals only is recommended. Otherwise a rinsing step might need to be applied after the passivation step. Depending on passivation agent elevated temperatures might be required. The system is then drained at maximum velocity.

Inspection: Objective is to ensure systems cleanliness by visual checks

All drums are opened and inspected and hand cleaned where required. Dead ends are inspected and cleaned where required. All accessible HRSG low points and temporary openings shall be used for inspection and utilized by high pressure water jetting or other means to remove solid deposits or foreign objects where required. Essentially the CCC (Chemical Cleaning Connections) of the HRSG re-heater and super heater low points will need to be cut to provide inspection access.

Cleanliness criteria for inspections:

- No loose particles, foreign objects or remaining water accumulation in the system (Puddles)
- Small amounts of rust and dust are acceptable
- Maximum particle size: 0.5 mm

Equipment used for inspections and re-cleaning must have adequate range to be able to 100% inspect and clean the entire low point section. HD image quality with movable camera head and light adaption to verify clean condition according cleanliness criteria in the entire pipe section

Preservation: Objective is to avoid corrosion and impurity accumulation on the cleaned surfaces.

Generally, preservation with dry air is applied. Preservation shall be initiated as soon as possible after chemical cleaning completion. Regular checks of the preservation status shall be done and documented.

C. General Guidelines on Air Blowdowns

There are several proven methods available for cleaning steam pipes by blowing down with either steam or air. A method of cleaning that has been used with success is the proper acid cleaning followed by the compressed air blowdown. This procedure can be use instead of steam blow. Compressed air used during air blowing shall be free of oil & water.

Air blowing must be preceded by a proper pre-operational acid cleaning of the steam parts with final HRSG steam side low points inspection, see description in per chapter VII.B .

Extended bypass operation at maximum load and various overnight shutdown are strongly recommended for each HRSG section prior to start up the Steam Turbine

Cleanliness measurement during air blowing uses the cleanliness validation method as defined for steam blowing. CFR calculation model shall be clearly described in the procedure considering system volume, blowing pressure and pressure drop to ensure CFR along the line being blown.

A log sheet should be used to record data for each blow. Data that should be recorded includes air blow number, date, time, blow starting pressure, blow ending pressure, blow duration, and visual observation (wet, some moisture, dry, debris, etc.). One log sheet should be kept for each system being blown down.

The HP , IP, LP and reheat steam systems will be air blown to targets.

Particular care shall be given during air blow and initial plant startup to check drain pot drip legs by blowing down the air/steam, abnormal clogging shall be investigated.

D. General Guidelines on Steam Blowdowns

Blowing down the steam piping with steam is a cleaning method that has traditionally been the method of choice in the power industry. The use of steam causes thermal cycling which helps to loosen debris, allowing it to be blown out.

Continuous Steam blowing can be either to atmosphere or to the condenser, continuous steam blow is the preferred method.

Note: Prior to blowing to the condenser, acid cleaning of the steam and water lines is mandatory. BOP steam lines can be cleaned by other methods such as high pressure water jetting or shot blasting along with a clean installation process instead of acid cleaning . In case some critical steam pipe section to the steam turbine is not in the steam blow path , an inspection of this piping shall be performed after the steam blow to condenser, depending of steam pipe routing & bypass take off this inspection can also be performed prior steam blow to condenser . Close attention is to be paid to dead legs in the path to the steam turbine, If the inspection indicates potential contamination, additional mechanical cleaning shall be performed. Steam blow to condenser is validated by target plates.

Discontinuous steam blowing: The procedure consists of pressurizing the boiler, terminating firing, and rapidly opening the temporary blow valve to depressurize the system. This cycle is repeated until the system is judged to be clean by use of targets. The steam is essentially saturated as the water stored in the boiler flashes as pressure decays. This is not the preferred method due the difficulty controlling transients & water carry over into the super-heaters.

Maintenance Practices - Cleanliness controls in maintenance practices are critical in preventing system contamination. The use of foreign material exclusion (FME) covers on system and pipe openings, good housekeeping/clean work areas (free of debris from related or non-related work), and visual inspections will reduce the possibility of introducing foreign material or debris into a piping system.

Visual Inspections - Visual inspections are essential to ensuring that foreign material is not introduced or left in the system. All piping and system openings should be inspected prior to final installation/closeout. Inspections should be performed using a flashlight and a mirror where practical and a borescope if required.

External Vibration - Vibration is not necessary in cleaning or blowing down the steam system because the medium reaches near supersonic speeds during the air or steam blow, thereby creating a greater vibrating force. For a typical steam piping diameter (16”), external attachments to produce a viable vibration would be cumbersome and redundant and, most likely, would add little to no value.

E. Contamination Evaluating Technique

The technique of evaluating cleanliness consists of using a steel target to evaluate the cleanliness of the steam system at rated CFR during a steam or air blow. For air- or steam blows to the atmosphere, the target shall be placed in the temporary piping. For steam blows to condenser, they are located in the plant permanent piping as for example in the LP & HRH bypass line.

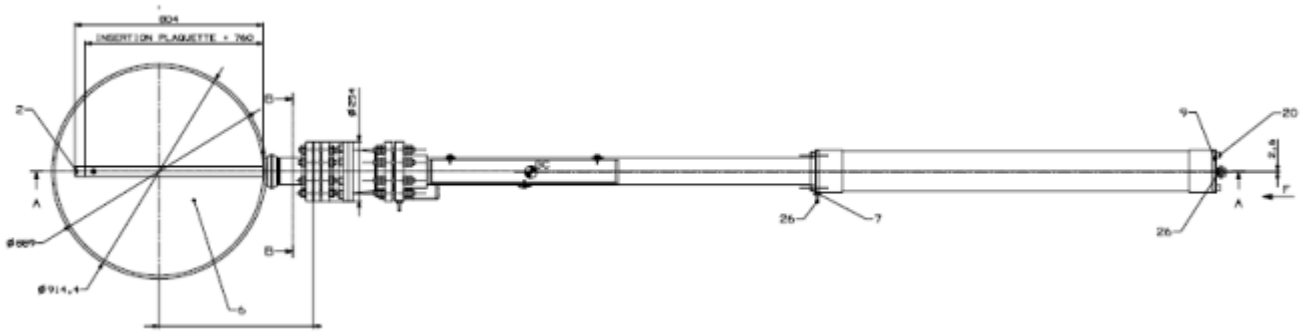

Figure 13. In-Line Target Assembly Example

Assuming that sufficient mass velocity has been achieved in the blowdown, the progress of the blow-down should be monitored by placing polished targets in the blowdown flow. Particles carried with the flow will cause pitting of the targets.

CFR (Cleaning Force Ratio) requirements:

During target plate exposure to the steam stream, the CFR at the outlet of the steam generator shall remain above ≥1.2 compared to Base load conditions.

Table 3. CFR Requirements

For BL condition	For extreme case conditions such as but not limited to: • Startup cases • Supplementary firing • Single unit operation for Multi units plant configuration
1.2 @ HRSG HP super heater outlet 1.2 @ Hot reheat outlet 1.2 @ LP super heater outlet 1.2 @ IP super heater outlet	1.03 @ HRSG HP super heater outlet 1.03 @ Hot reheat outlet 1.03 @ LP super heater outlet 1.03 @ IP super heater outlet

CFR ≥ 1.03 can only apply to extreme cases of operation reference (see Table 3) and where pre-operational cleaning (acid cleaning) was executed on the steam side of the HRSG & the BOP steam line. BOP steam lines can be cleaned by other methods such as high pressure water jetting or shot blasting along with clean installation process instead of acid cleaning .

Great care shall be taken to make sure that the worst operating conditions of the plant operation range are considered as reference for CFR calculation.

CAUTION

Must be taken to prevent piping configurations that require excessive inlet CFR's. Inlet CFR's, that significantly exceed 1.5 (i.e., 1.8 or greater), may cause system damage and should be avoided.

CFR is calculated using:

$$CFR = \left(\left(\frac{Q_c}{Q_{\max}} \right) \right)^2 x \frac{(PV)_c}{(PV)_{\max}} x \frac{(P_{\max})}{(P_c)}$$

Q_c = calculated flow during cleaning (lb/hr)

Q_{max} = max load flow (lb/hr)

$(PV)_c$ = pressure-specific volume product during cleaning at boiler outlet (ft^3/in^2)

(P_{max}) = pressure at max load flow at boiler outlet (psia)

(P_c) = pressure during cleaning at boiler outlet (psia)

$(PV)_{max}$ = pressure-specific volume product at max load flow at boiler outlet (ft^3/in^2)

Target Plate requirements:

Preferably the 40 mm width target plate as recommended in VGB shall be used, if this width is unpractical due to pipe diameter or other limitation, a target plate width of 25mm can be used . In case of 25 mm target plates the impact assessment shall be adapted into a 25mm x 64 mm surface.

The target plate's length depends on the piping diameter and preferably shall be at least 0.85 time the inner diameter of the piping where the target plate is inserted.

The target plates shall be made of carbon steel similar to S235JRG2 (St 37), ASTM A36

The hardness of the target plates shall be demonstrated being lower than 160 HB at ambient temperature.

The target plate dimensions shall be as follows:

Target plate width = 40mm
Target plate's length depends on the piping diameter and shall be at least 0.85 time the inner diameter of the piping where the target plate is inserted.

Measuring target plate's surface shall be polished up to a mirrored-finished surface roughness ($Ra \leq 0.2\mu m$).

Each target plates shall be identified with a single stamped marked number.

The installation of target plates directly downstream of pipe bends shall be avoided. Not less than 5 times the nominal width of the line in which the target plate is installed is considered the guide value for an undisturbed inlet section upstream of the target plate.

Target time exposure:

For continuous steam blow, target is exposed during ~ 10 min at required CFR

For discontinuous steam blows & air blow, target is exposed during the entire deflation period, 2 successful consecutives target plate are required for discontinuous steam blows & air blow.

As minimum two sets of target plates with start-up and shutdown/cooling down phase must be compared. The target plates of the last cycle must fulfill the steam blowing criteria

Impact criteria:

The whole target plate exposed surface shall be assessed first to identify the reference area.

Reference area is a square area of 40 x 40 mm selected where the most frequent/largest impacts are observed on the target plate.

Note: In case the measuring surface of a target plate should be damaged (impact, scratch) before its u se, the default can be marked and documented before the plate insertion if it is minor. Those minor da mages will not be accounted during the plate assessment after its use. Plates with major defaults on their measuring surface shall be scrapped.

Steam circuit cleanliness is considered sufficient if the amount of impacts on the reference area is not exceeding the following:

Less than 4 impacts > 0.5 mm (dia. of equivalent impact surface)

Less than 10 impacts > 0.2 mm (dia. of equivalent impact surface)

No impact > 1 mm (dia. of equivalent impact surface)

The use of a precision scale measuring magnifier (x 8 –
x 12; 0.1 mm scale on lens) is recommended to evaluate the amount and size of the impacts.

Note: For un-round impact, diameter of an equivalent circular surface must be considered

Figure 14. Precision scale measuring magnifier

Deviating from this standard, thereby falling short of meeting these acceptance criterion, could endanger the safe and efficient operation of the steam turbine and associated components, shorten the operating life cycle of the turbine or components, and negatively impact the long-term performance of the steam turbine.

F. Safety Considerations

Among the many other safety items to bear in mind in an industrial environment, the following apply to the material discussed in this article. Low point collection of chemical cleaning solution in valves and drains can be a personnel hazard. Site management should be aware of this, and supervisors should prevent craft labor from putting themselves in such a position as to be endangered by this hazard. During air blows, there exists a danger when purging low point drains due to the very low temperatures that could cause cold-related injuries. Conversely, during steam blows, personnel should be aware of the inherent danger in working with and around the high temperatures of steam.

G. Exception For GT Steam Cooled Unit

First stage cooling steam used in the Steam Cooled H-type gas turbine is a critical system.

Procedures and criteria that are recommended in this document are not applicable to an H-type installation. Consult Dwg 362A2412 for further guidance regarding this matter.

VIII. WATER SYSTEM CLEANLINESS AND ACCEPTANCE CRITERIA

Water wash, water injection, wet compression, and cooling water are all controlled systems. Water wash and systems should be maintained at NAS 10 level, water injection and wet compression at NAS 8 level, cooling water systems should be maintained at NAS class 12 level (refer to Table 1 and Table 2).

A. Contamination Measuring Technique

Sites should use the following guidelines to measure system cleanliness.

During system flushes, flushing effluent should be captured through a flushing cloth (lint free rag) until no debris is found. A water wash flushing procedure for F class units is contained in reference 16. This section serves as contamination measuring augmentation to that procedure.

- The effluent sample is measured against Table 1 to ensure the system meets NAS level requirements.
- The sample should be free of visual contamination and debris for an acceptable level of cleanliness. Two consecutive acceptable samples obtained are required to verify the cleanliness of the system or portion of the system that is being certified.

Verifying and maintaining a clean water system will help to ensure proper operation and help attain maximum performance of the system and components.

IX. SUMMARY

The values listed in Table 4. System Summary Chart are representative of the standard requirements for clean operation.

Specific requirements for cleanliness written in GE specifications (MLI A125, GEK121901, GEK116944 etc.) or in GE commissioning procedure might be different from the table below according to product factory cleanliness and scope of work at site and shall take precedence over the present GEK.

Table 4. System Summary Chart

System Noun Name	Criticality	NAS Class	Specifics
Lubricating Oil, Seal, lift	Critical	NAS 6	H2O content <100 ppm (.01%).
Hydraulic Oil	Critical	NAS 6	H2O content <100 ppm (.01%) High Pressure, Servo Valve use.
Liquid Fuel	Controlled	NAS 10	H_2O content <1000 ppm (0.1%)
Gas Fuel GT On Base	Critical	NA	Gas Fuel Specs in GEI 41040F
Gas Fuel Off Base	Controlled	NA	Gas Fuel Specs in GEI 41040F
Air Systems-General	Controlled	N/A	
Air Systems-Service/Shop Air	FME	N/A	
Steam-First Stage Cooling (H-Type)	Critical	N/A	
Steam-General	Controlled	N/A	
Water Wash Systems	Controlled	NAS 10	
Water Injection & Wet Compression Systems	Controlled	NAS 8	
Cooling Water Systems	Controlled	NAS 12	

References

1. D 6439-99, Standard Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems.
2. ISO TR 10949, Hydraulic Fluid Power-Methods for Cleaning and for Assessing the Cleanliness Level of Components.
3. ML A125, Lubricant Oil System Flushing Instruction
4. GEK 46506D, Steam Turbine Lube Oil (Recommended Properties & Maintenance Practices)
5. Global Filtration Technology Handbook of Hydraulic Filtration, Parker Filtration
6. GEI 41047H, Turbine Liquid Fuel Specifications
7. GE specification 362A2412, Gas turbine System and Component Cleanliness Requirements
8. GEI 41040, Process Specification Fuel Gases for Combustion in Heavy-Duty Gas Turbines
9. DWG 366A2803, General Piping Cleanliness requirements, Pipe
10. DWG 361A6439, Cleanliness Spec, On-Base Piping

11. Dwg 363A4220, Water Wash Flushing Procedures
12. PFI Standard ES-5, Cleaning of Fabricated Piping
13. National Aerospace Standard (NAS) Bulletin 1638
14. VGB S513 Internal Cleaning of Water-Tube Steam Generating Plants and Associated Pipework
15. GEK121901, Flushing Recommendations - Lube Oil System for STF Steam Turbine with SPL Generator
16. GEK116944, Flushing Recommendations for Turbine oil systems with motor driven main oil pumps
17. GEK116771, Fuel Supply System Cleaning for Gas Turbines

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