1.0 PURPOSE

This specification describes the minimum requirements for the cleaning, handling and packaging of oxygen service piping and components. This applies to new installations, repairs, and alterations to piping, vessels, and instrumentation tubing. This does not apply to oxygen gauges which are cleaned in accordance with ASME B40.100 – 2013.

Component cleanliness is critical in oxygen systems because of the inherent fire hazards associated with oxygen. In order for any fire to burn, there are 3 mandatory components:
   1) Fuel (piping components)
   2) Oxidizer (the oxygen fluid inside of system)
   3) Ignition mechanisms (Ignition maybe caused by of a variety of mechanisms such as particle impact, compression heating, flow-induced heating, etc.)

Proper cleaning eliminates some potential ignition sources. The following contaminants must be removed:
   - Hydrocarbon oils or greases
   - Particulate matter including loose or loosely adhered rust or mill scale, shop dirt, sandblast media, filings, chips, loose weld spatter, etc.
   - Organic films including paints, varnishes, fluxes, rust protectants, nonvolatile residue (NVR), etc.
   - Water, moisture
   - Unapproved pipe thread lubricants, gaskets sealants or anti seize compounds
   - Others

Mandatory requirements in controlling ignition sources in oxygen systems, excluding good design, are:
   1) Start clean: all components must be cleaned for oxygen service
   2) Verify clean: all components must be inspected
   3) Maintain Clean: maintain clean during installation / maintenance activities

2.0 START CLEAN

A written procedure is required to perform oxygen cleaning. The procedure must be detailed enough to allow an untrained individual to effectively clean components and include, at minimum, the following steps:

2.1 VALIDATION

The written procedure must be validated for both NVRs and particulates by a quantitative verification method (see Section 3.0) performed by a third party. The procedure shall be validated at the beginning of each contract. For contracts longer than 1 year duration, the procedure shall be validated yearly. For critical components, Vale has authority to increase quantitative inspection frequencies.
Procedure validation can occur using a part forming the contract lot.

2.2 DISASSEMBLY

All component surfaces that are exposed to oxygen shall be cleaned / inspected, thus disassembly is required.

2.3 PRE-CLEANING

Pre-cleaning is used to remove gross contaminants and is typically performed outside of the clean room. Some examples include: mechanical cleaning (grit, sandblasting), aqueous detergents, solvents, ultrasonic tanks, brushes, spray nozzles. The type of cleaning depends on type and size of parts.

2.4 RINSING

Rinse between uses of different fluids until visually clean.

2.5 FINAL CLEANING

This cleaning occurs inside of the cleaning facilities. Cleaning facilities shall be cleaned, reasonably isolated from other working areas and organized to prevent cross contamination of mixing clean and unclean components.

The specific cleaning procedure is dependent on type of parts being washed. Recommended methods include:

- For tubing: ultrasonic tank or spray nozzles
- For sintered filters: ultrasonic tanks
- For pressure transducers: spray nozzles
- For piping: semi aqueous cleaning

For all methods, parts shall be fully submerged in heated fluids, and procedure may include multiple, sequenced heating baths. Softgoods shall be exposed to heated fluid for maximum of 10 minutes. For large piping, valves, only surface exposed to oxygen is required to be fully submerged.

2.6 RINSING

Parts shall be rinsed until visually clean using heated water. Cascading rinse maybe be used.

2.7 DRYING

If quantitative tests are required (see SPEC-83060), they shall be performed prior to drying.
All oxygen components shall be dried by either oven, vacuum oven, or dry nitrogen purge. Nitrogen shall be dry (dew point between -40°F and -60°F) and free of contaminants in accordance with ASTM D4285.

2.8 RE-ASSEMBLY

Particles can be generated when assembling threaded connections. Sequence assembly to be able to blow out particles. Use compatible lubricants, and use sparingly. If piping tape is used, ensure that no part of the tape goes inside the pipe/joint by leaving last thread clear.

Any item left in the line can create an ignition mechanisms, and a final visual examination is required before final assembly to ensure welding dams, fire blankets, bolts, nuts, welding consumables, etc are not left in line.

2.9 BLOWING

Assembled parts shall be blown using dry, clean nitrogen and particles captured and removed prior to installation. It is important that the purge flowrate is higher than the operating flowrate. Nitrogen shall be dry (dew point between -40°F and -60°F) and free of contaminants in accordance with ASTM D4285.

2.10 PACKAGING / LABELLING

Packaging (or bagging) shall be suitable to protect the component from damage, contamination and prevent moisture from oxidizing surfaces (especially for ferrous items). Packaging details may vary depending on the component’s size or delivery method but some examples would be sealing in polyethylene bags, single or double layer, sealing pipe ends with plastic plugs, sealing flange ends with flange covers, purging with clean, dry air or nitrogen, using vapour phase inhibitor paper, etc…

Include any warnings such as contains VPI paper, under pressure, purged with nitrogen, etc. All packaging shall be accompanied by a label specifying:

CLEANED FOR OXYGEN SERVICE
CLEANED BY: Individual and company name
CLEANED TO SPECIFICATION: specification name
INSPECTED BY: Individual and company name
INSPECTION METHOD: Inspection technique
DATE:

2.11 MINIMUM TRAINING REQUIRED / RECORD KEEPING

The procedure shall state the minimum training requirements and training frequency to perform oxygen cleaning and specify how training records shall be recorded.
All cleaning tools shall be oxygen cleaned / qualitatively inspected prior to use. Personnel shall wear appropriate clothes and gloves to prevent contamination. Cleaned components shall be protected from contamination prior to assembly.

### 3.0 VERIFY CLEAN

Target cleanliness level:

- **Solids/particulates:** Level 300 ASTM G93
- **Nonvolatile residue (NVR):** 0 - 66 mg/m² (6 mg/ft²) ASTM G93 level C

At the discretion of Vale’s Oxygen Authority or designate (member of Divisional Oxygen Committee), the minimum required cleanliness level may deviate from the above based on a risk assessment.

Inspections are required to validate part cleanliness.

**Quantitative Inspection Techniques**
- Solvent Extraction Method (Particulate & NVR)
- Gas Blowdown (Particulate)
- Total Organic Carbon (NVR)

**Qualitative Inspection Techniques**
- White Light (Particulate & NVR) – See SPEC-83060 for details
- Black Light – Ultraviolet (Particulate & NVR)
- Wipe Test (Particulate & NVR)
- Water Break Test (NVR)

Inspection details and minimum requirements are detailed in SPEC-83060 and ASTM G93.

### 4.0 MAINTAIN CLEAN

In general, the area surrounding oxygen equipment should be treated as a hazardous location, using the same strict caution as with highly flammable gases. The following precautions should be taken:
- Non-sparking tools should be used
- Workers have clean PPE with no residual oils / greases
- Workers wear clean gloves at all times.
- All open ended oxygen systems are wrapped with clean plastic, secured with tape, until assembly.
- Rags that have been used to wipe up spills should be kept away from work areas and not carried in pockets.

When opening up pipelines in an operating plant (specifically NRC, EW, FBR, and Furnace), additional precautions to those listed above shall apply:
- Piping / fittings around area to be opened shall be cleaned for 10’ around each opening
- The area around the opening shall be assessed for cleanliness / sneak circuits (i.e.: particles falling from piping above). If necessary, area shall be hoarded to prevent contamination.
- The cleanliness opening on both sides of the joint shall be verified using a quantitative method.

5.0 REFERENCE DOCUMENTATION

The following documents are related to this specification and shall be used to their latest revision:

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
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<tbody>
<tr>
<td>ASME B40.100</td>
<td>Pressure Gauges and Gauge Attachments</td>
</tr>
<tr>
<td>ASTM D4285</td>
<td>Standard Method for Indicating Oil in Compressed Air</td>
</tr>
<tr>
<td>ASTM G-93</td>
<td>Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments</td>
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<tr>
<td>ASTM Manual Series MNL36</td>
<td>Safe Use of Oxygen and Oxygen Systems</td>
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<tr>
<td>CGA G-4.1</td>
<td>Cleaning Equipment for Oxygen Service</td>
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<td>CGA G-4.3</td>
<td>Commodity Specification for Oxygen</td>
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<td>CGA G-4.4</td>
<td>Oxygen Pipeline Systems</td>
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<tr>
<td>EIGA IGC Doc 13</td>
<td>Oxygen Pipeline Systems</td>
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6.0 REVISION AND TRANSITION NOTES

Revision notes describe: what was changed, and if applicable, why it was changed, and the plan to implement the change, including whether changes are retroactive. 

**Note:** The revision notes are a summary of the changes and may not necessarily be a complete list.

A risk code is entered for each revision and if applicable, the revision notes will describe how risk was addressed for the revision.

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<td>B</td>
<td>Risk has been addressed for this revision by the reviewer and approver. Low risk or no new hazards identified.</td>
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<td>C</td>
<td>For this revision, a PHR or other risk management tool has been used to address risk and minimize hazards. This risk assessment has been documented and is available through Central Engineering.</td>
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<td>MDF</td>
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<td>2013/02/22</td>
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<td>2</td>
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<td>A</td>
<td>M.Fogarty</td>
<td>B.Morris</td>
<td>2017/02/07</td>
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<td>3</td>
<td>Added minimum requirements for cleaning procedures, cleaning verification for maintaining cleaning during assembly / maintenance</td>
<td>B</td>
<td>K.L.Robin</td>
<td>M.Fogarty</td>
<td>2018/05/28</td>
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