Company Standard

# Component Cleanliness Standard

## Purpose

This specification defines the cleanliness requirements for oil lubricated piece parts, in terms of general requirements, maximum allowed particle size in microns and maximum allowed mass of contaminants (milligrams per part mass, mg/kg; milligrams per meter of hose, mg/m; and milligrams per square meter of the part's fluid-wetted area, $mg/m^2$). This is a multiple variation specification (see paragraph 1.2).

THIS DOCUMENT IS INTENDED TO BE USED BY BOTH EXTERNAL SUPPLIERS AND NIFTYLIFT INTERNAL QUALITY DEPARTMENT.

## Issue control

**Out of date when printed**

| Issue | Date | Change |
|---|---|---|
| 1 | 16/02/2016 | Original |
| 2 | 18/02/2016 | Amendment to page 4 |
| 3 | 01/03/2016 | Format Update |
| 4 | | |

## Departments involved

| | | | |
|---|---|---|---|
| ☒ Design, Eng., Dev. | ☒ Purchasing | ☐ Sales | ☐ Human Resources |
| ☒ Production Eng. | ☒ Quality | ☐ Marketing | ☐ Accounts |
| ☐ Production | ☐ Service | | |

## Reviewers

| | | |
|---|---|---|
| Author | Stephen de Caen | Research Manager |

## Contents

# 1 Introduction

## 1.1 Scope

This specification defines the cleanliness requirements for oil lubricated piece parts, in terms of general requirements, maximum allowed particle size in microns and maximum allowed mass of contaminants (milligrams per part mass, mg/kg; milligrams per meter of hose, mg/m; and milligrams per square meter of the part's fluid-wetted area, $mg/m^2$). This is a multiple variation specification (see paragraph 1.2).

# 2 Application

## *2.1* Type 1 *Components*

Unit parts and assemblies such as electro-hydraulic valves, hydraulic pumps and motors, castings, housings and filters.

## *2.2* Type 2 *Components*

Applies to hydraulic tank assemblies and cylinders.

## *2.3* Type 3 *Components*

Applies to piece parts (components) or assembly surfaces with customised contamination restrictions as defined by the manufacturers' drawings. Typically enhanced cleanliness levels compared to other component types.

## *2.4* Type 4 *Components*

Applies to hoses and hose assemblies cleaned with the Standard Basic Cleaning method.

## *2.5* Type 5 *Components*

Applies to hoses and hose assemblies cleaned with special hose cleaning processes, such as the Projectile Cleaning Method or by Flushing.

# 3 General Requirements

1. Abrasive dust and cleaning shot shall be removed.

**Note:** Weld slag, spatter, heat treat scale, machine chips and all other evidence of manufacturing shall be removed.

2. There shall be no evidence of sand remaining on castings. Visual inspections devices such as mirrors or bore scopes shall be used where needed.

3. Surfaces that will come into contact with fluids shall be free of corrosion and corrosive products.

4. All surfaces shall be protected against corrosion and recontamination until assembly into the next higher level.

5. The specified cleanliness level shall be met at the time of assembly into the next higher level.

6. If demagnetization of all electro-hydraulic components is required, demagnetize the part to a maximum measured level of 500ut (5 gauss) refer to paragraph 6.1.

7. Protective fluids such as rust preventatives (RP) and volatile corrosion inhibitors (VCI), shall be clean before they are applied to piece parts (there shall be no visible debris). Although RP and VCI oils are not contaminants themselves, the contaminants they contain are. No material shall be removed or exempted from contributing to the mass of contaminants tested. If the viscosity is low enough, it is recommended to filter protective fluids until ISO 4406 Code 18/16/13 or cleaner. Protective fluids shall be stored in clean containers, handled with clean tools and managed with clean processes.

8. Plugging and Masking – Best practice shall be used to eliminate false contamination measurements of components caused by the introduction of contaminants during test.

9. All reasonable measures shall be taken to ensure that no external paint is introduced into the wetted ports during preparation of the component for test.

# 4 Cleanliness Requirements

## 4.1 Gravimetric Analysis

Gravimetric analysis shall be regularly conducted by Niftylift and suppliers to ensure parts comply with the maximum particle size and maximum mass of contaminants shown in Table 1.

| Component Type | Max Particle Size (µm) | Max No. of Particles above size in Parentheses (µm) | Max Mass of Contaminants Allowed | | |
|---|---|---|---|---|---|
| | | | mg/Part mass | mg/m hose | mg/m$^2$ |
| Type 1 | 600 | 0(600) | Per Figures 1&2 | N/A | N/A |
| Type 2 | 1200 | 3(1000) | | | |
| Type 3 | As defined by manufacturers drawing. | | | | |
| Type 4 | Per table 3 | | N/A | Per table 3 | N/A |
| Type 5 | | | | | |

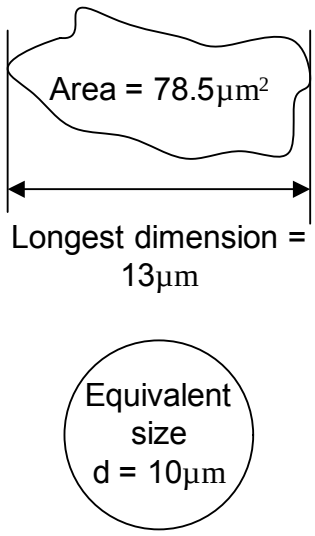
Table 1.

## 4.2 Particle Sizes

Particles can be metallic (e.g. rust, weld slag, grinding debris or abrasive materials), or nonmetallic (e.g. sand or paint). If the particle breaks up when probed, only the resulting, smaller particles shall be counted towards size. Probing is defined as the minimum amount of force needed to break the particle without damaging the filter patch. Probing shall be done on the filter patch.

Example particle sized by APC
calibrated as per ISO 11171 (new NIST)

*"diamater of equivelant proj. surface"*




## 4.3 Contaminant Mass

The maximum mass of contaminants allowed is shown in tables 1-3 and figure 1. The mass of the contaminants found on the parts shall be expressed in mg per part mass or mg per meter of hose.

| Piece Part Mass (kg) | Max Mass of contaminants allowed (mg) |
|---|---|
| ≤1 | 1 |
| 1-40 | $C_A = 1 \times M_c$ |
| >40 | 40 |
| $M_c$ = Numerical Value of the Mass of the part in kilograms | |
| $C_A$ = Maximum mass of contaminants allowed, expressed in milligrams | |

Table 2.

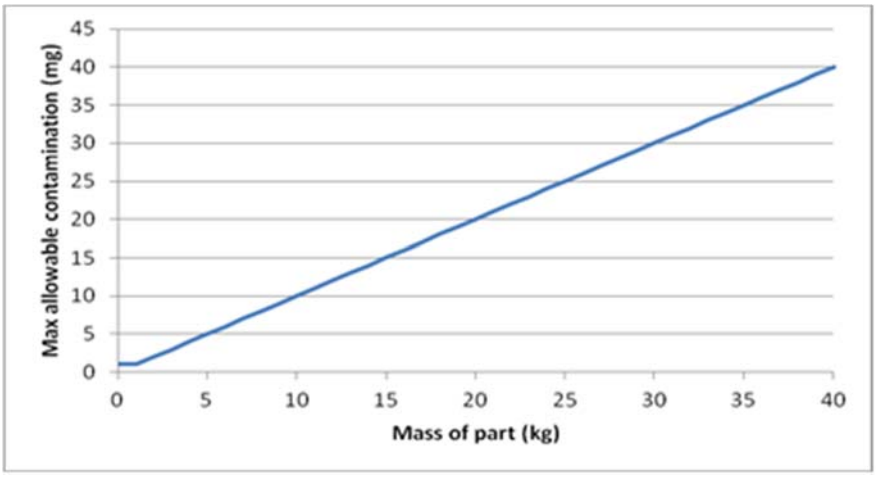



Figure 1. Maximum mass of contaminants allowed for parts up to 40kg

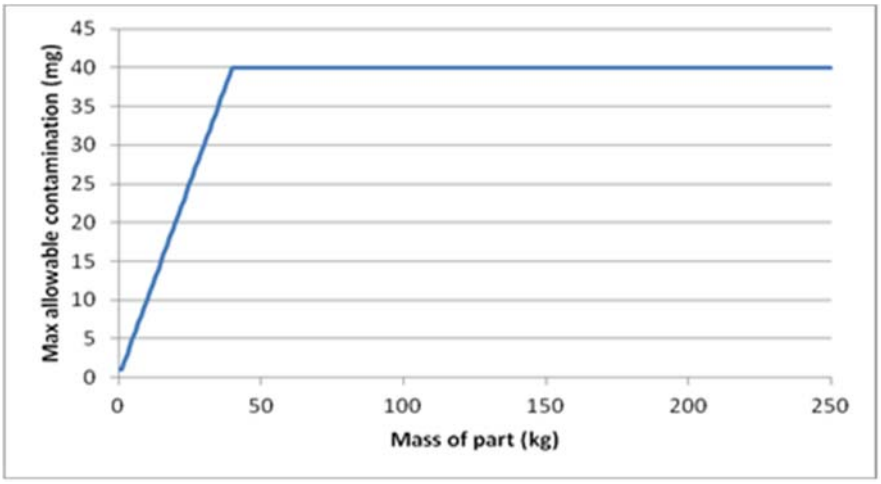



Figure 2. Maximum mass of contaminants allowed for parts up to 250kg

## 4.4 Cleanliness requirements for hoses and hose assemblies.

The cleanliness requirements for hoses and hose assemblies shall be controlled as shown in table 3.

| | | | Particles allowed per meter of hose | | Max mass of contaminants allowed. | |
|---|---|---|---|---|---|---|
| | **Hose diameter** | **Largest Particles in microns** | **Number of particles per meter of length** | **Longest particle dimension in microns** | **Milligrams per meter (mg/m)** | **Max milligrams (mg)** |
| Standard basic Cleaning. **Type 4 components** | Up to 19.1mm | 600 | 2 | 600-1200 | 3 | 15 |
| | >19.1mm <31.8mm | 600 | 2 | 600-1200 | 5 | 25 |
| | >31.8mm | 600 | 3 | 600-1200 | 7 | 35 |
| Projectile cleaning method or flushing. **Type 5 components** | Up to 19.1mm | 300 | 2 | 300-600 | 2 | 10 |
| | >19.1mm <31.8mm | 300 | 2 | 300-600 | 4 | 20 |
| | >31.8mm | 300 | 3 | 300-600 | 6 | 30 |

Table 3.

# 5 Fibers

1. Fibers shall not be counted toward the particle size but their mass shall be added to the total mass of contaminants.
2. A fiber is defined as any non-metallic, soft material (e.g. cotton, hair, rubber) with a length to diameter ratio greater than 10:1.

# 6 Special Recommendations

## 6.1 Residual Magnetic Fields

Residual magnetic fields attract and hold ferrous particles that will transfer to the next higher assembly. Although demagnetizing all parts is not required by this specification, it is good manufacturing practice to demagnetize ferrous parts and check for residual magnetic fields as part of a comprehensive cleaning program. Ferrous particles will adhere to magnetic parts when the gauss levels are above 200μT (2 gauss) and will tightly adhere if the levels are 1000μT or higher. This prevents the particles from being washed off in a standard manufacturing environment but in an operating system where fluid velocity is large enough to wash these particles off, particles will cause system damage or failure.

# 7 Inspection method – piece part cleanliness

## 7.1 Piece part cleanliness test preparation

### 7.1.1 Filter Preparation

1. Using tweezers, place the 5 micron filter patches in individual clean and residue-free pans. Clean and dry the pans (e.g. large Petri dishes) before use. Prepare enough filter patches for all samples taken plus 2 additional patches.
2. Place the pans and filters into an oven set between 102°C and 104°C for 1 hour MIN.
3. Remove pans from the oven and place them in a desiccant dryer for 2 hours or overnight.
4. Place a clean, dry weigh pan on the scale, tare the pan weight, place a dry filter patch into the weighing pan and proceed to weigh the dry filter patches. Remove the filter patch and place in a cover holder. Label the holder with an appropriate identification mark. Record the weight along with the identifying mark used for the filter patch holder.

### 7.1.2 Fluid Preparation

1. Prior to use, the solvent shall be filtered twice through a 1.2 micron or finer filter patch. To avoid false high mass readings, ensure that the solvent chosen completely dissolves the rust preventatives used to protect the parts to be examined.
2. The clean solvent shall be kept in a closed and clean container.

The solvent bottle shall be marked “Clean Solvent” along with the trade name of the solvent and any other mandated identification marks.

### 7.1.3 Brush Preparation

1. All brushes used must be inspected before use. Check for loose, damaged or otherwise unacceptable bristles.
2. The brush shall be clean. Cleaning shall be done using an acceptable solvent and a vigorous sloshing of the brush in the solvent. Remove excess solvent before use.

# 8 Cleanliness test – Small parts

1. Before each test, rinse the filtration assembly and collection vessel with clean solvent. Place the solvent in a container that is clean, closed and labeled (e.g."Used Solvent"). If the solvent will be re-used (not best practice), it shall be filtered through a 5 micron filter patch prior to repeating Paragraph 7.1.2(1) to ensure solvent is clean.
2. Place the part(s) to be tested in appropriate sized vessel to collect the rinsing solvent.
3. Using the hand pump, pressurize the sprayer bottle to a pressure that will provide a stream of liquid that will not splash excessively. A recommendation value is 20±5 PSI.
4. Place part(s) in the pan so that you will be able to direct the flow from the spray bottle into all cavities, bore holes and onto all fluid contacting surfaces. You shall turn the part so that all fluid-wetted areas receive equal flow. The amount of fluid or time of fluid impact is arbitrary. A good rule of thumb is to give the area of the part 5 to 10 seconds of spray.
5. This is spray that impacts all exposed fluid-wetted areas. Repeat each spray 3 times. Be aware of the sprayer pressure. Do not let the sprayer pressure fall below a point that a vigorous stream of solvent is not produced. The pressure of the bottle shall be maintained at the recommended value of 20±5 PSI.
6. All openings shall be brushed with a nonmetallic brush for at least two strokes in each direction, in between washings one and two. Every attempt shall be made to reach with the brush as much of the fluid-wetted area as possible. The brush shall have an OD at least 10% greater than the orifices you shall brush. All openings greater than 10 millimeters shall be brushed.
7. Remove the part(s) and let the residual fluid drain back into the collection vessel. Turn the parts to make sure as much of the fluid is collected as possible. If necessary, suspend the part(s) over the collection pan by some method until all of the solvent is collected.
8. If the fluid is immediately filtered, proceed to "**8. Cleanliness test-small parts(9)"**. If the collected fluid is to be brought to another area for filtration, transfer the fluid with the contaminants to a clean and labeled bottle and close it with a clean cap. When you reach the filtration area proceed to paragraph "**8. Cleanliness test-small parts(9)"**.
9. Filter the fluid collected in paragraph "**8. Cleanliness test-small parts(8)"** through a 5 micron filter patch prepared in paragraph "**7.1.1 Filter Preparation**". Rinse out the collection pan/bottle with enough clean solvent (prepared per paragraph "**7.1.2 Fluid Preparation**") and filter it through the same 5 micron patch. Rinse the filter patch and the wall of the funnel with enough clean solvent to transfer all particles to the patch.
10. Protect the rinsed equipment until ready for the next filtration.
11. Using tweezers, remove the filter patch from the filter holder and place it back into the labeled holder it was taken out of. Place the holder in a safe place. Record the part identification and the number of part(s) used in the test. Repeat paragraphs "**8. Cleanliness test-small parts(1)"** through "**8. Cleanliness test-small parts(11)"** for each test.
12. After all tests are done, determine the weight of contaminant retained on each filter patch by placing them in a drying pan 10-15 minutes, followed by 1 hour in an oven at 102°C to 104°C. Do this for every filter patch used. Remove the pans and place them in a desiccant dryer for a minimum of 2 hours (until it is dry). Remove the filter patch(es) from the pan, weigh it and subtract the weight of the tare weight of the filter patch determined in paragraph **"7.1.1 Filter Preparation (4)"**. The difference is the ***mass of contaminants*** on the filter patch (mg). Record this number and place the filter patch in a marked, closed container. Proceed with the microscopic inspection (Article 10).

# 9 Cleanliness test - Internal volume only

1. This test is for parts that have a sealable internal volume that can contain the flushing solvent.
2. Install clean plugs in all openings except one large enough to use as a fluid fill port.
3. Pour enough clean (filtered) solvent into the piece part's internal volume to effectively extract the contaminants (volume is likely to increase proportionally to the fluid-wetted surface area and internal part volume). Manufacturers should conduct internal tests to determine the correct volume of clean solvent needed to extract all contaminants for the parts to be analyzed. Plug the opening used as a fluid fill port.
4. Rotate the part so that the clean solvent effectively rinses all internal surfaces (e.g. rotate 180° clockwise and anti-clockwise for a minimum of 3 times. Invert the part 180° from the initial position and rotate the part 180° clockwise and anti-clockwise a minimum of three times).
5. Filter the solvent through a 5 micron patch following steps **"3 to 12"** of Paragraph **"8. Cleanliness test – Small parts".** Determine and record the mass of the contaminants collected on the filter patch.

# 10 Microscopic Inspection

View each filter patch under a stereo microscope (minimum magnification of 30x). Count, measure and record the largest particles, as well as the different types of particles and fibers found (e.g. sand, steel, copper, blue shop towel etc.), further Scanning Electron Microscopy (SEM) Analysis may be required to determine the origin of any contaminants found.

# 11 Determining compliance and reporting results.

## 11.1 Mass of Contaminants

If the **mass of contaminants** extracted from the part (mg), exceeds the maximum mass of contaminants allowed (as of part mass - tables 1,2 or hose length - table 3), mark the filter patch as reject; otherwise, mark as acceptable.

## 11.2 Number and sizes of particles

If the **number and sizes of particles** on the patch exceed the applicable requirements (table 1 or table 3), mark the filter patch as rejected; otherwise, mark it as acceptable.