1.0 SCOPE

This specification defines cleanliness levels applicable to finished engine components and assemblies. This is a multiple variation specification (See Article 3.0).

2.0 APPLICATION

2.1 This specification is applicable to component or assembly surfaces in contact with fuel, engine lube oil, inlet air, exhaust gases to the turbocharger, and fluid in cooling system passages.

2.2 This specification is applicable to L1 through L2 NPI product structures.

2.3 Packaging and preservation materials and methods shall ensure conformance to the prescribed 1E2500 specification level throughout the manufacturing and assembly processes.

2.4 Assemblies shall be inspected in the assembled state to consider debris generated as a function of the assembly process while disallowing consideration of any debris generated as a result of disassembly.

Note: Assemblies which may become damaged as a result of the inspection process shall not be assigned 1E2500 Specification.

3.0 DRAWING DESIGNATIONS

3.1 The levels of cleanliness are normally specified in the following areas:

3.1.1 1E2500A

3.1.1.1 Engine component or assembly surfaces in contact with filtered fuel.

3.1.1.2 All common rail components between the primary and secondary fuel filers and all common rail return components such as low pressure return lines.

3.1.1.3 The primary filter base, HEP pump, fuel pump, and transfer pump.

3.1.1.4 CRS, or other emissions system regeneration devices, components, or assemblies between the primary filter and final filtration or screening point, prior to the fuel nozzle.

3.1.2 1E2500B - Component or assembly surfaces (unless covered by 1E2500E) in contact with filtered engine lube oil or inlet air.

3.1.3 1E2500C - Component or assembly surfaces in contact with unfiltered fuel, unfiltered engine lube oil, or exhaust gases to the turbocharger.

3.1.4 1E2500D

3.1.4.1 All fuel system component or assembly surfaces (unless covered by 1E2500A).

3.1.4.2 1E2500D$_a$ - All intake valve actuator (IVA) and variable valve actuator (VVA) component surfaces. New electro-hydraulic control valve systems shall be covered by 1E2500D.

Note: 1E2500D$_b$, 1E2500D$_c$, and 1E2500D$_d$ are fulfilled by 1E2500D.

3.1.5 1E2500E - Component or assembly surfaces in contact with filtered engine lube oil that lubricates crankshaft bearings or feeds filtered supply oil to electro-hydraulic control valve systems.

3.1.6 1E2500G - Assembly level component groups and cooling system passages with customized contamination restrictions defined per Figure 1.

Cleanliness Level	Largest Particle Allowed, In Microns (a)			Maximum No. Particles Allowed Per Given Particle Length, In Microns (a)		Maximum Mass Allowed (e)		Abrasives (Oxides) >40 µm (b)
	X	Y	Z	#	X	mg/ m²	mg	>40 µm
1E2500A	1200	500	150	4	500-1200	170	10	Allowed (c)
1E2500B	1200	1200	200	4	500-1200	230	16	Allowed
1E2500C	2000	2000	200	4	1000-2000	535	-	Allowed
1E2500D	750	75	75	2	500-750	8	1.0	Not Allowed
1E2500D_a	1200	250	100	2	500-1200	24	2.0	Not Allowed
1E2500E	1200	500	100	2	500-1200	170	10	Not Allowed
1E2500G	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)

Note: 1E2500D_b, 1E2500D_c and 1E2500D_d are fulfilled by 1E2500D.
Note: Particle restrictions are per test sample.

(a) Refer to Figure 2.
(b) Not applicable to 3500 and 3600 Series Engines.
(c) For Fuel Systems Components Only – No more than 10 abrasives greater than 40 micron size per cleanliness patch.
(d) Restrictions defined by print. For assemblies only – print defined restriction limits may be equal to but not more restrictive than the least restrictive component level specification within that assembly.
(e) Maximum mass allowed shall be less than mass per surface area (mg/m^2) and absolute mass (mg) as indicated by the respective values in the chart above.

Figure 1

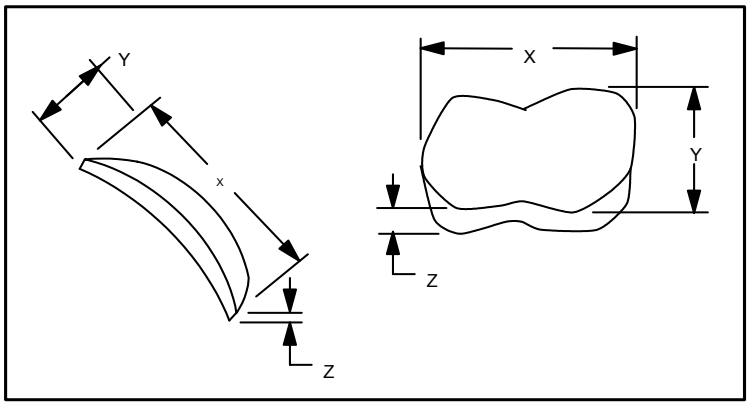

Figure 2

4.0 CLEANING OPERATIONS

This specification does not state how a part is to be cleaned. The method of cleaning is a manufacturing option, and will not be stated on the engineering drawing.

5.0 REQUIREMENTS - GENERAL

5.1 All cleanliness evaluations are based on flushing the specified area with solvent, filtering the flushed solvent onto a membrane filter patch, measuring particle dimensions with a microscope, and measuring total particle mass with an analytical balance.

5.2 Maximum allowable residual magnetic flux density is 0.0001 tesla (1 gauss) for fuel system components and 0.0005 tesla (5 gauss) for all other parts. This is measured by a gaussmeter (see ML1037).

5.3 Any part specifying a 1E2500 cleanliness level for a defined area shall meet 1E2500C on the undefined areas, except water passages. Water passages shall be as clean as required for processing or as defined by 1E2500G. If desired, “Assembly Line Clean” is jointly determined by supplier and customer.

5.4 Components and assemblies produced to a 1E2500 cleanliness level shall maintain compliance to that level throughout storage, transportation and assembly processes.

5.5 Particle Size

5.5.1 Particles to be measured for size are metallic, rust (either free or loosely attached), slag, sand, and other abrasives. If particles are fragile and break up when gently probed (gently probing will not tear membrane filter patch), only the remaining solid pieces are to be measured for specification conformance.

5.5.2 Soft materials such as rubber and plastic are to be counted only under 1E2500D and 1E2500E. Individual strands of fibers (defined as having a thickness and width of 20 microns or less) such as plastic and cotton shall not be counted under 1E2500D and 1E2500E unless they are in a woven mass such as a piece of filter media, shop towel, etc.

5.6 Mass - All particles are to be counted in the mass determination for all levels of this specification.

5.7 Mass and size restrictions (see Figure 1) shall be applied to each test sample individually. A test sample is defined by the print or a documented and controlled quality system inspection procedure. If a test sample is not defined on the print or inspection procedure, the specified cleanliness level applies to all surfaces of the component.

6.0 REQUIREMENTS - CLEANLINESS LEVELS

6.1 Restrictions are based on five (5) categories:

6.1.1 Dimensions of largest particle allowed.

6.1.2 Maximum number of particles exceeding a given length.

6.1.3 Maximum mass per surface area.

6.1.4 Maximum mass, absolute (except 1E2500C).

6.1.5 Abrasive oxides greater than 40 microns.

6.1.5.1 Abrasive materials are defined as particles exhibiting a crystalline structure and a Mohs Hardness of 6 or higher.

6.1.5.2 Typical examples of abrasives include aluminum oxides, aluminum zirconium, silicon carbides, silicon oxide (sand), cubic boron nitride (CBN), boron carbide, or tungsten carbide. Abrasive particles greater than 40 microns apply to 1E2500D and 1E2500E.

6.1.5.3 Glass in the form of beads or other non-crystalline shapes shall also be considered abrasive particles

7.0 TEST PROCEDURE

Refer to Manufacturing Practice ML1037 for general 1E2500 testing. For information regarding fuel systems contact the Pontiac Materials Laboratory.

8.0 REFERENCES

Abbreviations	1E0011
Caterpillar Manufacturing Practice	ML1037