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ESTABLISHING ISO TARGET CLEANLINESS CODES FOR MOBILE HYDRAULIC SYSTEMS USING A SYSTEMIC APPROACH

Presented by:

Ken Nicholas
Global Technical Support,
Hydraulics Group Training Manager
The Donaldson Company

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- **Objective:**

- **Learn the recommended practices and procedures to apply the principles of using a systemic approach to establish a target cleanliness code for hydraulic systems used on mobile equipment.**

- **Assumption: Each attendee is familiar with the ISO standard (3-digit coding system) for establishing a target cleanliness code for operating hydraulic systems, per ISO 4406-1999 (E).**

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***SYSTEMIC (Affecting the Whole Body)**

***Criteria for Using A Systemic Approach:**

- **Equipment Duty Cycle (Continuous or Intermittent?) Affects Component Life.**
- **System Operating Pressure (low, medium or high)**
- **System Fluid Temperature (Typical & Start-Up)**
- **Operating Environment**
- **Required Cleanliness Level (RCL) or Target Cleanliness Code (TCC)**
- **System Components (Including the Fluid)**
- **Expected Useful Life**
- **Safety Issues**

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- **Systemic Approach…**

- **Contamination Code (TCC), per ISO 4406-1999(E).**

Simply Defined: A set of numbers used as a shorthand method for describing the particle size distribution of contaminates in hydraulic oil based on fluid samples taken from an typical system, analyzed, per the ISO standard.

Example: 21/18/15 represents the number of 4, 6 and 14 micron size particles per ml of fluid, per the ISO standard as noted. The lower the ISO code, the cleaner the oil. (Refer to the chart shown in your handout packet)

ISO 4406: Allocation of Scale Numbers

Table — Allocation of scale numbers

Number of particles per millilitre		Scale number
More than	Up to and including	
80 000	160 000	24
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2,5	5	9
1,3	2,5	8
0,64	1,3	7
0,32	0,64	6
0,16	0,32	5
0,08	0,16	4
0,04	0,08	3
0,02	0,04	2
0,01	0,02	1
0,005	0,01	0
0,002 5	0,005	0,9

ISO Cleanliness Standard 4406: 1999(E)

No. of Particles per 1 ml of Fluid		ISO Range Number	No. of Particles per 1 ml of Fluid		ISO Range Number
More than	Up to and Including		More than	Up to and Including	
80,000	160,000	24	20	40	12
40,000	80,000	23	10	20	11
20,000	40,000	22	5	10	10
10,000	20,000	21	2.5	5	9
5,000	10,000	20	1.3	2.5	8
2,500	5,000	19	0.64	1.3	7
1,300	2,500	18	0.32	0.64	6
640	1,300	17	0.16	0.32	5
320	640	16	0.08	0.16	4
160	320	15	0.04	0.08	3
80	160	14	0.02	0.04	2
40	80	13	0.01	0.02	1

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- **Please note:**
- **ISO Cleanliness Code Scale:**
- **Is logarithmic, a single digit increase doubles the number of particles per milliliter for each size, vice versa.**
- **Example: TCC is 16/14/11, reading is 17/15/12.**

Cleanliness Levels Based on Pressure

System Type	Recommended Cleanliness Levels (ISO Code)
Low Pressure – manual control	20/18/15 or better
Low to Medium Pressure – electro-hydraulic controls	19/17/14 or better
High pressure - servo-controlled	16/14/11 or better

Typical ISO Cleanliness Recommendations

Here are some typical ISO cleanliness recommendations from component manufacturers.

(These are guidelines; always check the ratings specified by the manufacturer of your specific components.)

Pressure	<3000 PSI ≤ 210 Bar	>3000 PSI >210 Bar
Pumps		
Fixed Gear Pump	19/**17**/**15**	18/**16**/**13**
Fixed Vane Pump	19/**17**/**14**	18/**16**/**13**
Fixed Piston Pump	18/**16**/**14**	17/**15**/**13**
Variable Vane Pump	18/**16**/**14**	17/**15**/**13**
Variable Piston Pump	17/**15**/**13**	16/**14**/**12**
Valves		
Directional (solenoid)	20/**18**/**15**	19/**17**/**14**
Pressure (modulating)	19/**17**/**14**	19/**17**/**14**
Flow Controls (standard)	19/**17**/**14**	19/**17**/**14**
Check Valves	20/**18**/**15**	20/**18**/**15**
Cartridge Valves	20/**18**/**15**	19/**17**/**14**
Load-sensing Directional Valves	18/**16**/**14**	17/**15**/**13**
Proportional Pressure Controls	18/**16**/**13**	17/**15**/**12***
Proportional Cartridge Valves	18/**16**/**13**	17/**15**/**12***
Servo Valves	16/**14**/**11***	15/**13**/**10***
Actuators		
Cylinders	20/**18**/**15**	20/**18**/**15**
Vane Motors	19/**17**/**14**	18/**16**/**13**
Axial Piston Motors	18/**16**/**13**	17/**15**/**12**
Gear Motors	20/**18**/**15**	19/**17**/**14**
Radial Piston Motors	19/**17**/**15**	18/**16**/**13**

* Requires precise sampling practices to verify cleanliness levels. Source: Vickers

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- **Systemic Approach, continued…**
- **What is the system operating temperature?**
- **What is the system operating pressure, low, medium high? (refer to the chart in your handout packet)**
- **Once the TCC has been established, then select the proper grade of filter media needed to initially achieve and maintain the target based on the filter filter manufacturer's recommendation. (3, 6, 10um?)**

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Systemic Approach, continued…

- **Once the TCC is established, begin a routine fluid sampling program to verify/confirm that the TCC is being achieved/maintained, overtime. This is an important step in confirming that system cleanliness is being maintained and the system is being protected.**

- **Recommended sampling intervals is dictated by system duty cycle and other factors, typically, if your running a high pressure (3,000+) system then you should be sampling every 15-30 days, lighter duty, less often. Some equipment OEMs recommend every 500 hours.**

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Replenishment Fluid:

- **Any make-up oil added to the system, either from standard drums, totes or bulk containers should be pre-filtered to eliminate any residual contamination present in the so-called new clean oil.**

- **Use a standard filter cart or similar device with a high efficiency (Beta rated) filter media designed for single pass filtration. Typically, the filter media for this application should have a minimum beta rating of B5(c)=1000.**

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***Conclusion, Summary:**

- **By applying the principles outlined above, a typical mobile equipment hydraulic system can achieve the following economic benefits:**

- **Will maintain the proper cleanliness levels that will provide certain cost savings related to component service life, fluid life, decreased equipment downtime, increased uptime and extended system life.**

- **Contamination related downtime is virtually eliminated.**

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***Conclusion, Summary:**

- **Equipment maintenance intervals are extended.**
- **Minimal to non-existent wear metals present in the hydraulic fluid are virtually eliminated.**
- **Proper grade of filtration media, when applied and serviced will maintain the TCC insuring oil cleanliness levels during operation of the mobile equipment.**

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***Conclusion, Summary:**

- **Individual filter assemblies selected should include full flow pressure and return line, with the appropriate grade of media to insure that the TCC is initially achieved and maintained over time, thus, providing economic value.**

***Follow the recommended steps to apply the principles of using a systemic approach when establishing an ISO target cleanliness code for the hydraulic systems used on your mobile equipment.**

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Thank you for your time and attention.

Handout materials will include a copy of the published paper, along with selected Donaldson promotional literature.

If I can be of service or assistance, your welcome to contact me at your convenience.