

**M11 EGR
Lubricant Performance Test**

Report Packet Version No.

Method

Conducted For:

	V = Valid; The reference oil / non-reference oil was evaluated in accordance with the test procedure.
	I = Invalid; The reference oil / non-reference oil was not evaluated in accordance with the test procedure.
	N = Results cannot be interpreted as representative of oil performance (non-reference oil) and shall not be used in determining an average test result using multiple test criteria.

	NR = Non-Reference Oil Test
	RO = Reference Oil Test

Stand:	Engine:	Engine Run No:
End Of Test Date:	End Of Test Time:	
Oil Code:		
Formulation / Stand Code:		
Alternate Codes:		

In my opinion the test _____ been conducted in a valid manner in accordance with Test Method Dxxxx and the appropriate amendments through the information letter system. The remarks included in this report describe the anomalies associated with this test.

Submitted By: _____

_____ Testing Laboratory

_____ Signature

_____ Typed Name

_____ Title

M11 EGR Lubricant Performance Test
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M11 EGR Lubricant Performance Test
Form 3
Summary Of Test Method

The M11 EGR Lubricant Performance Test is an engine-dynamometer test which evaluates the ability of a lubricant to minimize crosshead wear, filter plugging, sludge build-up, and top ring weight loss. This test is a two-stage, steady state test (constant speed and load). Stage A is 50 hours and is run with retarded fuel injection timing to produce elevated soot levels in the oil. Stage B is 50 hours and is run under heavy load conditions to induce wear. The stages are run in sequence (Stage A followed by Stage B) three times for a total test length of 300 hours.

The test engine is a Cummins M11 diesel engine with EGR. It is an in-line six cylinder, four-stroke, turbocharged engine with electronically controlled fuel injection. A two-h break-in is conducted prior to each test since a new engine build is used for each test.

M11 EGR Test Conditions

Parameter	Stage A	Stage B
Time, h	50	50
Injection Timing, °BTDC	16 min	32
Speed, r/min	1800	1600
Fuel Flow, kg/h	58.0	64.4
Intake CO 2%	0.97 - 1.09	0.78 - 0.85
Inlet Manifold Temp., °C	80	65.5
Coolant Out Temp., °C	65.5	65.5
Fuel In Temp., °C	40	40
Oil Gallery Temp., °C	115	115
Intake Air Temp., °C	Record	Record
Intake Air Pressure, kPa absolute	Record	Record
Intake Manifold Pressure, kPa absolute	300 Minimum	320 Minimum
Exhaust Back Pressure, kPa absolute	107	107
Crankcase Pressure, kPa	Record	Record
Coolant System Pressure, kPa	99 - 107	99 - 107
Power, kW	Record	Record
Torque, Nm	Record	Record
Pre-turbine Exhaust Temp., °C	Record	Record
Tailpipe Exhaust Temp., °C	Record	Record
Oil Sump Temp., °C	Record	Record
Inlet Air Dew Point, °C	Record	Record
Inlet Air Humidity, kg/kg	Record	Record
Oil Gallery Pressure, kPa	Record	Record
Oil Filter Delta P, kPa	Record	Record

**M11 EGR Lubricant Performance Test
Test Results Summary
Form 4**

Laboratory:	EOT Date:	EOT Time:
Stand:	Engine:	Engine Run No.:
Formulation/Stand Code:		
Oil Code:	Engine Kit S/N:	

Date Test Started				
Start Time				
Test Length				
TMC Oil Code ^A				
Laboratory Oil Code				
SAE Viscosity				
TGA Soot % At 50 h				
TGA Soot % At 250 h				
Average TGA Soot % 0 - 300 h (≥ 4.6)				
Total Oil Consumption, kg				
	Adj. Average Crosshead Mass Loss (mg)	Filter Plugging Delta P (kPa)	Average Sludge Rating (merits)	Avg. Top Ring Weight Loss (mg)
Original Result				
Transformed Result ^B				
Correction Factor ^B				
Corrected Transformed Result ^B				
Severity Adjustment ^B				
Final Transformed Result ^B				
Final Result				

Last Stand Reference Results				
Test Number:				
Oil Code				
Test Length				
TMC Oil Code				
EOT Date				
EOT Time				
Stand Calibration Expiration Date				
TGA Soot % AT 50 h				
TGA Soot % AT 250 h (8.0 - 9.0)				
Average TGA Soot % 0 - 300 h (≥ 4.6)				
Total Oil Consumption, kg				
	Adj. Average Crosshead Mass Loss (mg)	Filter Plugging Delta P (kPa)	Average Sludge Rating (merits)	Avg. Top Ring Weight Loss (mg)
Original Result				
Transformed Result ^B				
Correction Factor ^B				
Corrected Transformed Result ^B				
Final Transformed Result ^B				
Final Result				

^A Reference Tests Only

^B Filter Plugging Delta P Value in Transformed Units

**M11 EGR Lubricant Performance Test
Form 5
Operational Summary**

Laboratory:	EOT Date:	EOT Time:
Stand:	Engine:	Engine Run No.:
Formulation/Stand Code:		
Oil Code:		

Controlled Parameters	Parameter	Units	QI Threshold	EOT QI ^A	Target		Average		Samples ^B	BQD ^C	Over/Under Range ^D
	Speed	r/min	0.000		1800	1600					
	Fuel Flow	kg/h	0.000		58.0	64.4					
	Coolant Out	°C	0.000		65.5						
	Fuel In	°C	0.000		40						
	Oil Gallery	°C	0.000		115						
	Intake Manifold	°C	0.000		80.0	65.5					
	Exhaust	kPa	0.000		107						
Non-controlled Parameters	Parameter	Units	Typical Values ^E		Average						
	Torque	N-m	TBD	TBD							
	Power	kW	TBD	TBD							
	Intake CO	%	0.97 - 1.09 ^F	0.78 - 0.85 ^F							
	Blowby	L/min	TBD								
	Coolant In	°C	TBD								
	Intake Air	°C	TBD								
	Pre-Turbine (F)	°C	TBD								
	Pre-Turbine (R)	°C	TBD								
	Tailpipe	°C	TBD								
	Fuel	kPa	TBD								
	Oil Gallery	kPa	TBD								
	Coolant	kPa	99 - 107								
	Intake Manifold	kPa	TBD								
	Crankcase	kPa	TBD								
Intake Air	kPa	TBD									

^A QI values above the threshold are acceptable by the Cummins Surveillance Panel. QI values below the threshold may not be considered acceptable based on an engineering review. See the comments section of this report.

^B Total number of data points taken

^C Number of Bad Quality Data points not used in the calculation of the statistical measures

^D Number of points clipped by over/under range limits

^E Typical values determined from reference oil test database

^F Intake CO₂ rates must be within specified range

**M11 EGR Lubricant Performance Test
Form 6
Crosshead Mass Loss Summary**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Location	Serial No.	Pretest Mass (g)	EOT Mass (g)	Mass Loss (mg)
1E				
1I				
2I				
2E				
3E				
3I				
4I				
4E				
5E				
5I				
6I				
6E				

Intake / Exhaust Summary	Intake		Exhaust	
	As Measured	Outlier Screened	As Measured	Outlier Screened
Average Crosshead Mass Loss (mg)				
Minimum Crosshead Mass Loss (mg)				
Maximum Crosshead Mass Loss (mg)				
Standard Deviation (mg)				
Outlier Crossheads Locations ⁴				

⁴ Location Designation. Example: 3E

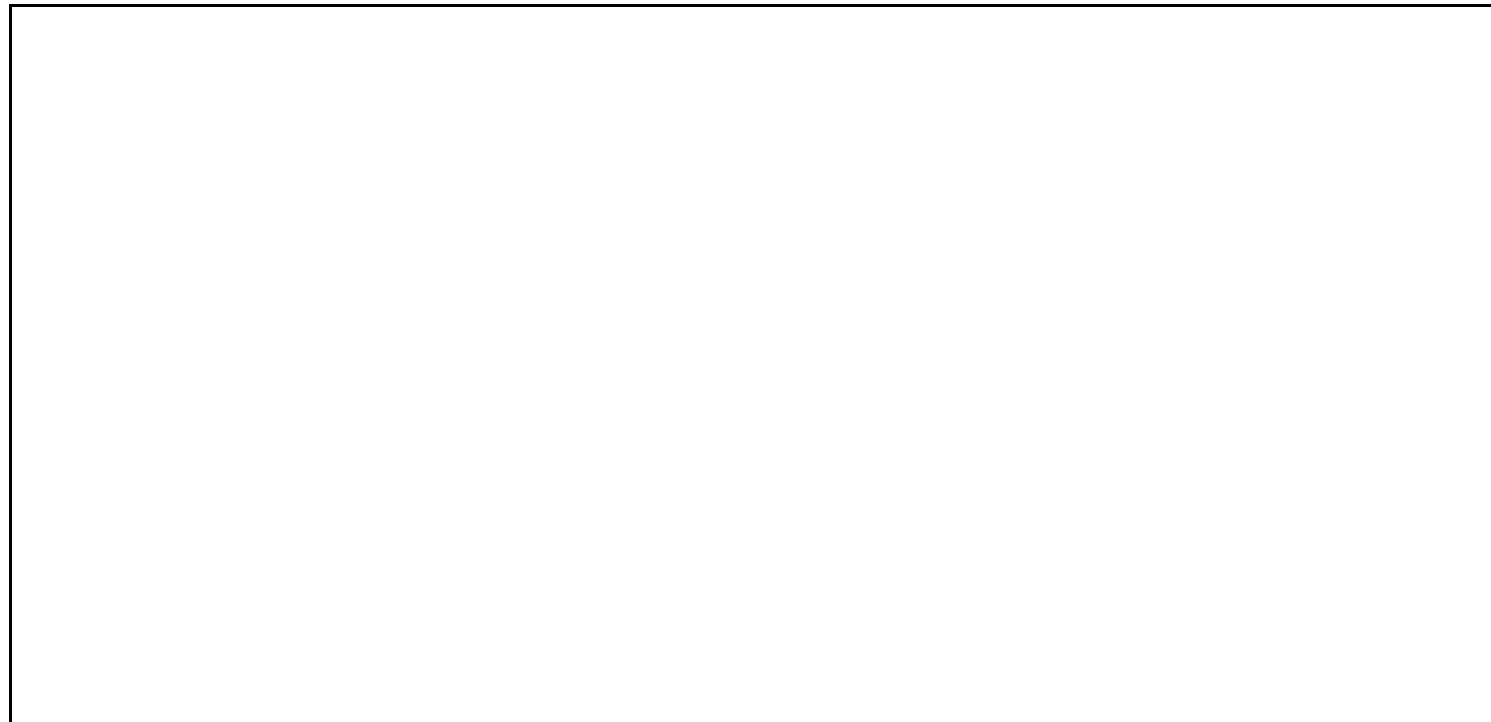
Overall Summary	As Measured	Outlier Screened	Adjusted to 4.6% Soot
Average Crosshead Mass Loss (mg)			
Minimum Crosshead Mass Loss (mg)			
Maximum Crosshead Mass Loss (mg)			
Standard Deviation (mg)			

**M11 EGR Lubricant Performance Test
Form 7
Oil Filter Delta Pressure Plot**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil code:		

OIL FILTER DELTA PRESSURE vs TEST HOURS

OIL FILTER DELTA P (kPa)



TEST HOURS

**M11 EGR Lubricant Performance Test
Form 8
Sludge Rating Summary**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Sludge Rating Summary

Sludge Depth	Valve Cover % of Area	Valve Cover Volume Factor	Oil Pan % of Area	Oil Pan Volume Factor
1/4A				
1/2A				
3/4A				
A				
AB				
B				
BC				
C				
D				
E				
F				
G				
H				
I				
J				
	Total Volume Factor:		Total Volume Factor:	
	Merit Rating:		Merit Rating:	
			Average Sludge Rating:	

**M11 EGR Lubricant Performance Test
Form 9
Rod Bearing Mass Loss**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Cylinder Number	Bearing Location	Pretest Mass (g)	Post-Test Mass (g)	Mass Loss (mg)
1	Upper			
	Lower			
2	Upper			
	Lower			
3	Upper			
	Lower			
4	Upper			
	Lower			
5	Upper			
	Lower			
6	Upper			
	Lower			

	Bearing Mass Loss
Average (mg)	
Minimum (mg)	
Maximum (mg)	
Standard Deviation (mg)	

**M11 EGR Performance Test
Form 10
Piston Rating Summary**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Unweighted Demerits										
Piston Number	Lands				Grooves			Under Crown	Oil Cooling Gallery	Total Demerits
	1	2	3	4	1	2	3			
1										
2										
3										
4										
5										
6										
Average Demerits										
									Average Total Unweighted Demerits	

Parameter	Piston Number						Average
	1	2	3	4	5	6	
TGC							
TLC							

**M11 EGR Lubricant Performance Test
Form 11
PISTON 1 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																				
Carb	Grooves				Lands				Dep. Factor	Groove		Lands				Oil Cooling		Under Crown		
	No. 1		No. 2		No. 1		No. 2			No. 3		No. 3		No. 4		A,%	Dem.	A,%	Dem.	
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	
on	HC -1.0																			
	MC -0.5																			
	LC - .25																			
	Total																			
Varnish	8 - 9								7.5											
	7 - 7.9																			
	6 - 6.9																			
	5 - 5.9																			
	4 - 4.9								4.5											
	3 - 3.9																			
	2 - 2.9																			
	1 - 1.9								1.5											
	>0 - 0.9																			
	Clean		0		0		0		0	Clean		0		0		0		0		0
Total																				
Rating																				
TGC					Unweighted Deposits					Top Land Carbon					T.L. Flaked Carbon %					

**M11 EGR Lubricant Performance Test
Form 12
Piston 2 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																				
Carb	Grooves								Dep. Factor	Lands						Oil Cooling		Under Crown		
	No. 1		No. 2		No. 1		No. 2			Groove No. 3		Lands No. 3		Lands No. 4		A,%	Dem.	A,%	Dem.	
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	
n	HC -1.0																			
	MC -0.5																			
	LC - .25																			
	Total																			
Varnish	8 - 9																			
	7 - 7.9																			
	6 - 6.9																			
	5 - 5.9																			
	4 - 4.9																			
	3 - 3.9																			
	2 - 2.9																			
	1 - 1.9																			
	>0 - 0.9																			
	Clean		0		0		0		0	Clean		0		0		0		0		0
Total																				
Rating																				
TGC					Unweighted Deposits					Top Land Carbon					T.L. Flaked Carbon %					

**M11 EGR Lubricant Performance Test
Form 13
Piston 3 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																			
Carbon	Grooves				Lands				Dep. Factor	Groove		Lands				Oil Cooling		Under Crown	
	No. 1		No. 2		No. 1		No. 2			No. 3		No. 3		No. 4		A,%	Dem.	A,%	Dem.
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.				
Carbon	HC -1.0																		
	MC -0.5																		
	LC - .25																		
	Total																		
Varnish	8 - 9									7.5									
	7 - 7.9								4.5										
	6 - 6.9										1.5								
	5 - 5.9									Clean									
	4 - 4.9										0								
	3 - 3.9								0										
	2 - 2.9									0									
	1 - 1.9								0										
	>0 - 0.9									0									
Clean	0		0		0		0	Clean	0			0		0		0		0	
Total																			
Rating																			
TGC				Unweighted Deposits				Top Land Carbon				T.L. Flaked Carbon %							

**M11 EGR Lubricant Performance Test
Form 14
Piston 4 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																				
Carb	Grooves				Lands				Dep. Factor	Groove		Lands				Oil Cooling		Under Crown		
	No. 1		No. 2		No. 1		No. 2			No. 3		No. 3		No. 4		A,%	Dem.	A,%	Dem.	
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	
n	HC -1.0																			
	MC -0.5																			
	LC - .25																			
	Total																			
Varnish	8 - 9								7.5											
	7 - 7.9																			
	6 - 6.9																			
	5 - 5.9								4.5											
	4 - 4.9																			
	3 - 3.9																			
	2 - 2.9								1.5											
	1 - 1.9																			
	>0 - 0.9																			
	Clean		0		0		0		0	Clean		0		0		0		0		0
Total																				
Rating																				
TGC					Unweighted Deposits					Top Land Carbon					T.L. Flaked Carbon %					

**M11 EGR Lubricant Performance Test
Form 15
Piston 5 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																					
	Grooves									Lands						Oil Cooling		Under Crown			
	Dep. Factor	No. 1		No. 2		No. 1		No. 2		Dep. Factor	Groove No. 3		Lands No. 3		Lands No. 4		A,%	Dem.	A,%	Dem.	
		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%			Dem.	A,%	Dem.	A,%	Dem.	A,%					Dem.
C a r b o n	HC -1.0																				
	MC -0.5																				
	LC - .25																				
	Total																				
V a r n i s h	8 - 9																				
	7 - 7.9																				
	6 - 6.9									7.5											
	5 - 5.9																				
	4 - 4.9																				
	3 - 3.9									4.5											
	2 - 2.9																				
	1 - 1.9																				
	>0 - 0.9									1.5											
	Clean		0		0		0		0	Clean		0		0		0		0		0	
Total																					
Rating																					
TGC					Unweighted Deposits					Top Land Carbon					T.L. Flaked Carbon %						

**M11 EGR Lubricant Performance Test
Form 16
Piston 6 Deposit Ratings**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Total Piston Ratings Summary																					
Carb	Grooves								Dep. Factor	Lands								Oil Cooling		Under Crown	
	No. 1		No. 2		No. 1		No. 2			Groove No. 3		Lands No. 3		Lands No. 4							
	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.		A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.	A,%	Dem.
n	HC -1.0																				
	MC -0.5																				
	LC - .25																				
	Total																				
Varnish	8 - 9																				
	7 - 7.9																				
	6 - 6.9																				
	5 - 5.9																				
	4 - 4.9																				
	3 - 3.9																				
	2 - 2.9																				
	1 - 1.9																				
	>0 - 0.9																				
	Clean		0		0		0		0	Clean		0		0		0		0		0	
Total																					
Rating																					
TGC					Unweighted Deposits					Top Land Carbon					T.L. Flaked Carbon %						

**M11 EGR Lubricant Performance Test
Form 17
Ring Mass Loss Summary**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Cylinder	Top Ring			Second Ring			Oil Ring		
	Mass (g)		Mass Loss (mg)	Mass (g)		Mass Loss (mg)	Mass (g)		Mass Loss (mg)
	Pretest	EOT		Pretest	EOT		Pretest	EOT	
1									
2									
3									
4									
5									
6									
As Measured Results									
Average Mass Loss (mg)									
Std. Dev. Mass Loss (mg)									
Maximum Mass Loss (mg)									
Minimum Mass Loss (mg)									
Outlier Crosshead (cylinder number)									
Outlier Screened Results									
Average Mass Loss (mg)									

**M11 EGR Lubricant Performance Test
Form 19
Test Fuel Analysis (Last Batch)**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Fuel Supplier	Fuel Batch Identifier

Measurement	Specifications	Analysis		Test Method
		New	EOT	
Total Sulfur, % Weight	0.04 - 0.05			D 2662
Gravity, °API	34.5 - 36.5			D 1298
Hydrocarbon Composition				
Aromatics % Volume	28 – 33			D 1319
Olefin	Report			D 1319
Cetane Index	Report			D 4737
Cetane Number	42 – 48			D 613
Copper Strip Corrosion	1 Maximum			D 130
Flash Point, °C	54 Maximum			D 93
Pour Point, °C	-18 Maximum			D 97
Carbon Residue on 10% Residuum, %	0.35 Maximum			D 524 (10% Bottoms)
Water & Sediment, % Volume	0.05 Maximum			D 2709
Viscosity, cSt @ 40 °C	2.4 - 3.0			D 445
Total Acid Number	0.05 Maximum			D 664
Strong Acid Number	0.00 Maximum			D 664
Accelerated Stability	Tbd			D 2274
Saturates, %	Report			D 1319
Cloud Point, °C	Report			D 2500
Distillation, °C				
IBP	Report			D 86
10%	Report			D 86
50%	Report			D 86
90%	282 – 338			D 86
EP	Report			D 86

**M11 EGR Lubricant Performance Test
Form 20
Injector Adjusting Screw Mass Loss**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Screw #	Pretest Mass, g	Post-Test Mass, g	Mass Loss, mg
1			
2			
3			
4			
5			
6			
		Total	
		Average	

**M11 EGR Lubricant Performance Test
Form 22
Characteristics Of The Data Acquisition System**

Laboratory:	EOT Date:	EOT Time:
Test Number		
Stand:	Engine:	Engine Run No.:
Formulation / Stand Code:		
Oil Code:		

Parameter (1)	Sensing Device (2)	Calibration Frequency (3)	Record Device (4)	Observation Frequency (5)	Record Frequency (6)	Log Frequency (7)	System Response (8)
Temperatures							
Oil @ Filt.							
Fuel In.							
Intake Air							
Intake Man.							
Pre-Turb.							
Cool. Out							
Pressure							
Inlet Air							
Exhaust							
Oil Gallery							
Other							
Fuel Flow							
Speed							
Load							

Legend:

- (1) Operating Parameter
- (2) The type of device used to measure temperature, pressure, or flow
- (3) Frequency at which the measurement system is calibrated
- (4) The type of device where data is recorded
DL – Automatic data logger
C/D – Computer, using direct I/O entry
- (5) Data are observed but only recorded if off spec.
- (6) Data are recorded but are not retained at EOT
- (7) Data are logged as permanent record, note specify if:
SS – snapshot taken at specified frequency
AG/X – Average of X data points at specified frequency
- (8) Time for the output to reach 63.2% of final value for step change at input