Fluid Sealing Association

STANDARD

FSA-G-605-11

Standard Test Method for Determining *(m)* and *(y)* Loading Constants Applicable to Gasket Materials and Designs

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Standard Test Method for Determining *(m)* and *(y)* Loading Constants Applicable to Gasket Materials and Designs

1. Scope

This test method will establish criteria for determining standard loading constants that are referenced in current ASME pressure vessel design (Section VIII, Divs. 1 and 2). These constants are specific to this design criteria and should not be used as a guide for material selection on existing equipment or pressure vessels.

This standard may involve hazardous materials, operations and equipment. This standard does not purport to address safety measures associated with its use. It is the responsibility of the organization and/or individual performing these procedures to establish and employ appropriate safety practices that are associated with any test procedure.

2. Applicable Documents

ASTM Standards
F104 Classification System for Nonmetallic Gasket Materials
F586-79 Leak Rates Versus *y* stresses and *m* Factors for Gaskets (Originally adopted in 1979, reapproved in 1985 and discontinued in 1989.)
ASME Standards
B16.5 Steel Pipe Flanges and Flanged Fittings
Pressure Vessel Code, Section VIII, Divs. 1 and 2

3. Terminology

Definitions:
Gasket contact area – the area of the gasket that is under load from the flange surfaces. This only applies to the area of the gasket in direct contact with the flange face.
Leak rate – the leakage in cubic inches (cubic centimeters) of fluid per second passing through or around the gasket under the conditions of this test, reduced to standard.
Maintenance factor (*m*) – the dimensionless factor that defines the additional preload capability required in the flange fasteners to maintain the sealing pressure on a gasket after internal pressure is applied to a joint.
Yield factor (*y*) – the factor that represents the pressure in pounds-force per square inch (kilopascals or megapascals) on the contact area of the gasket that is required to provide a sealed joint, assuming minimal pressure and therefore a lack of hydrostatic end load effect on the assembly.

4. Significance and Use

This test method determines both the *y* stress and m factor as curves rather than as single or constant numbers. Constants for use as variables in ASME Section VIII code calculations can be derived from this data. End users may wish to select values from the curves which reach their desired maximum leak rate. Tests are often done with pre-established maximum leak rates, and the *y* and *m* values to achieve those rates are reported. Since *y* values are determined at a low pressure of 2 psig (0.14 barg) internal pressure, the predetermined maximum leak rates for the *y* values are usually much lower than for the m test.

This test method will only determine two general characteristics that are specific to the ASME design criteria. Many other factors should be considered when determining proper materials for existing equipment and pressure vessels. (i.e. Temperature resistance, chemical resistance, relaxation rates, accommodation of thermal cycling).

5. Apparatus

The test fixture or loading apparatus will consist of fixed platens that are hydraulically actuated. The load shall be monitored with a pressure transducer to ensure accuracy. A typical rig is shown in Figure 1. The surface finish of the sealing area shall meet rules stated in ASME B16.5 for acceptable surface finish with a roughness of 125-250 micro-inch (3.2-6.3 micro-meters). This finish shall be checked prior to each test with a surface comparator to ensure conformance. Test fixtures must have a containment system to capture the leakage outside the gasket. The leak containment system is not needed if flow is measured upstream of the fixture.

6. Test Specimen

The test specimen's description and flange orientation must be clearly detailed on the test report. The gasket sample size shall be 2 in. (50mm) inside diameter by 3 in. (75mm) outside diameter. The recommended specimen thicknesses are 1/16 in. (1.6mm) and 1/8 in. (3.2mm). Sample thickness must be reported in final results.

7. Conditioning

7.1 Condition the gasket in accordance with classification system F104 or as agreed upon between the purchaser and/or the manufacturer of the gasket specimen.

7.2 Ensure flange face is clean and free of defects, scratches and/or foreign material.

8. Procedure for Determining *y* Stress

8.1 Measure and record the initial gasket thickness.

8.2 Measure and record the surface finish of the flanges (see section 5)

8.3 Center the gasket on the flange face

8.4 Load gasket to 500 psi (3.45 MPa) surface stress

8.5 Pressurize the fixture to 2 psig (0.14 barg). (Media must be specified in the final reporting documentation)

8.6 Measure leak rate. If leakage cannot be controlled or is in excess of measurement device, proceed to step 8.8

8.7 Hold for 15 minutes and then record leakage rate.

8.8 Raise gasket stress to next load increment.

Repeat 8.6 through 8.7 in 500 psi (3.45 MPa) surface stress increments. Larger increments can be utilized with materials known to require higher seating loads.

8.9 Calculate the *y* stress as follows: $y = W/A_1$

Where: W = Total compressive force (lbs force or kg force)

A_1 = gasket area (in^2 or mm^2)

8.10 Plot the leak rate versus the *y* stress

8.11 Record the final thickness of the gasket

9. Procedure for Determining *m* Factor

A new gasket is utilized for the second portion of the test.

9.1 Measure and record initial gasket thickness.

9.2 Ensure flange facing is clean and free of contaminants and debris from previous test.

9.3 Center the gasket on the flange face

9.4 Apply a surface stress of 6770 psi (46.7 MPa).

9.5 Pressurize the vessel with media to 300psig (20.7 barg. Note: When calculating the *m* factor, the hydrostatic end force is subtracted from the total flange loading force. See formula in section 9.10

9.6 Measure leak rate. If leak rate exceeds maximum measurable leak rate, proceed to 9.8

9.7 Hold for 15 minutes and then record leak rate.

9.8 Repeat 9.6 through 9.7, decreasing load in incremental steps of 500 psi (3.45 MPa) surface stress or until leakage cannot be controlled. Increments may be varied based upon material characteristics and the material performance precedent. Note: It is possible to establish a standard

maximum leak rate at which the testing would be terminated once the load is decreased to the point where the leakages reaches or exceeds that predetermined rate.

9.9 Depressurize fixture and terminate test.

9.10 Calculate the leak rates for initial load and each decrease as follows:

Calculate the *m* factor as follows: $m = (W-A_2P)/A_1P$

Where: W = Total flange loading force (lbs force or kg force)

A_1 = gasket area (in^2 or mm^2)

A_2 = inside area of gasket (in^2 or mm^2)

P = Test Pressure (psig or barg)

9.11 Plot the leak rate versus *m* factor

9.12 Record the initial and final gasket thickness

9.13 Record the surface finish on the flange face

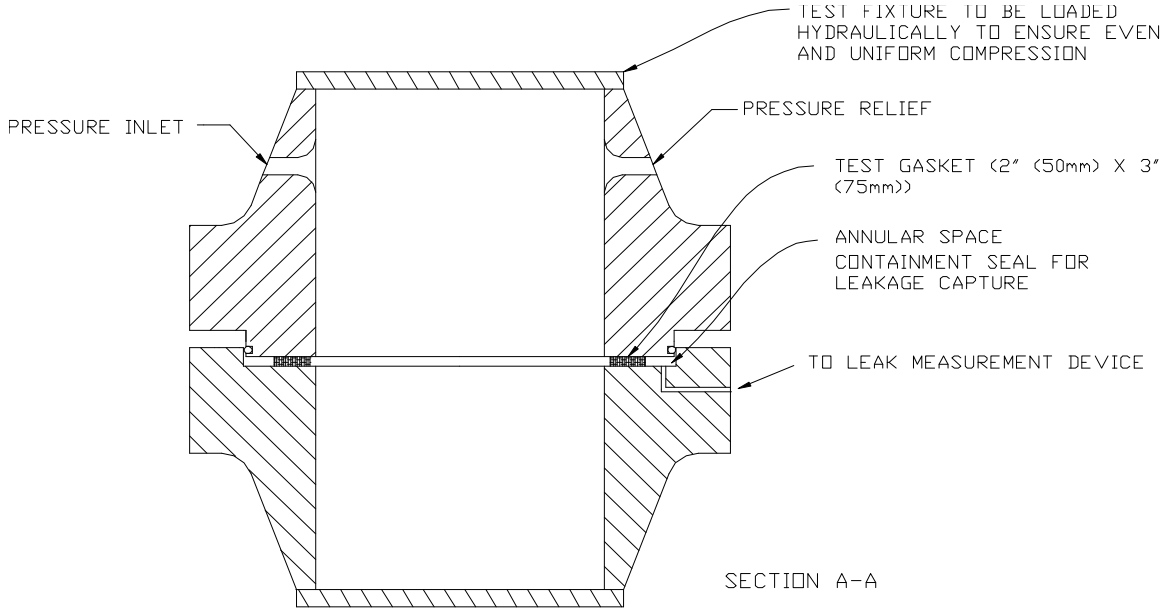
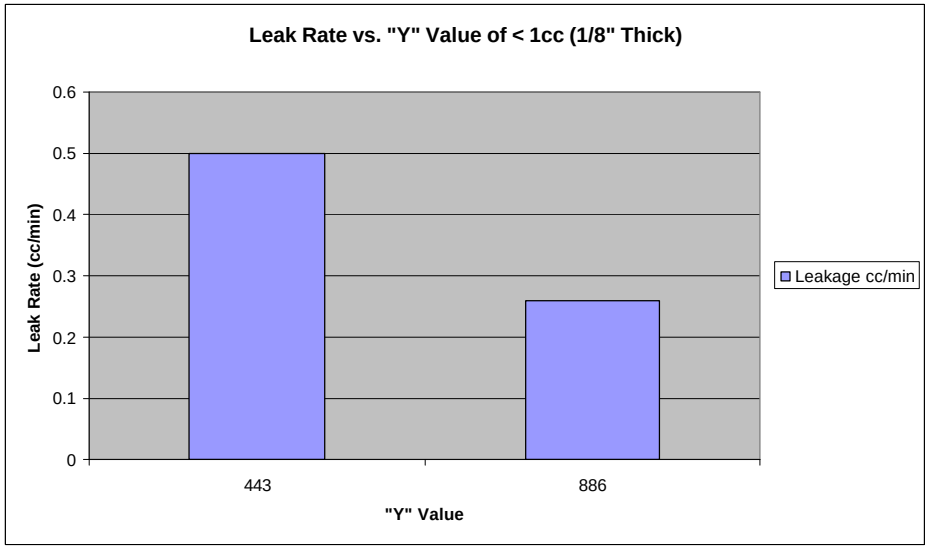
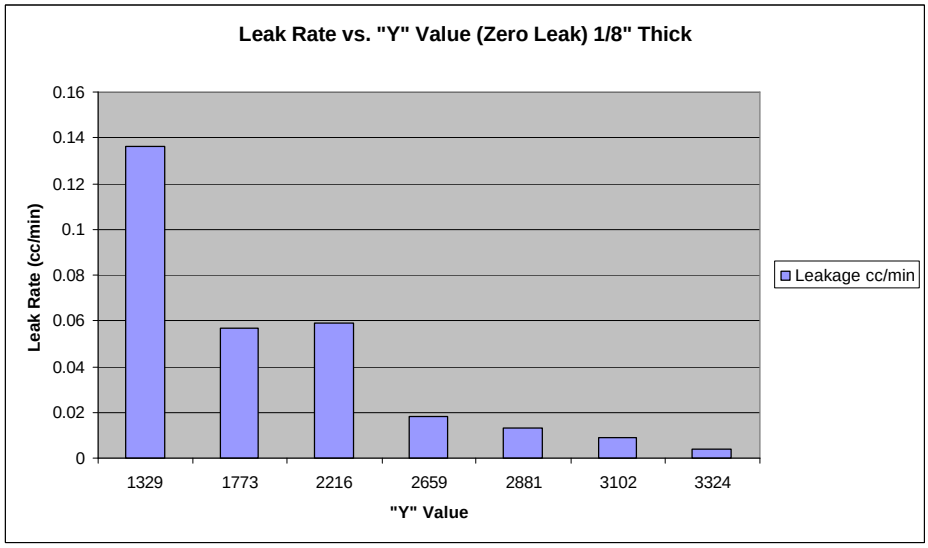


Fig. 1 Flange arrangement with hydraulically loaded platens

Test values determined by this method are based on controlled conditions at room temperature and therefore do not account for all conditions, including high temperatures and/or thermal cycling. Metallic or semi-metallic gaskets are often exposed to such conditions. Therefore further analysis is necessary to arrive at the proper design values. Consultation with the manufacturer is advised.





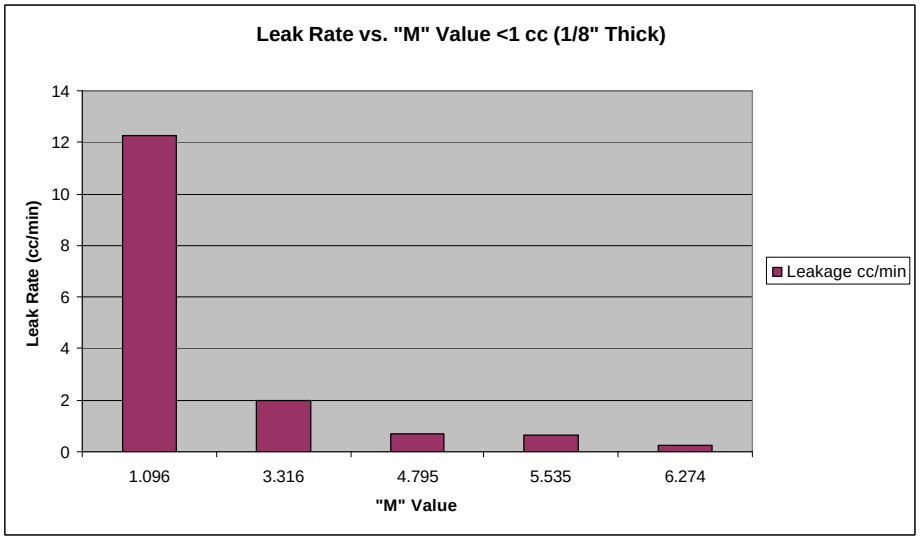


Fig. 2 Typical reports that represent leak rates and given stresses

APPENDIX

FSA *m* and *y* Round Robin Test Results (Determination of "*y*" Constant) (cc/min)

		Lab 1 PTFE 1	Lab 2 PTFE 1	Lab 3 PTFE 1	Lab 1 PTFE 2	Lab 2 PTFE 2	Lab 3 PTFE 2	Lab 1 PTFE 3	Lab 2 PTFE 3	Lab 3 PTFE 3
Unit Stress (psi)	0									
	500	0.0004	0.057102	0.0785	0.0018	0.0258	0.0253	N/A	0.07934	0.0901
	1000	0.000018	0.006577	0.0057	0.00022	0.0041	0.0087	N/A	0.00192	0.0079
	1500	0.0000006	N/A	0.0042	0.0000345	N/A	0.0043	N/A	N/A	0.0039
	2000	0.00000057	N/A	0.0034	0.0000339	N/A	0.0047	N/A	N/A	0.0022
	2500	0.00000053	N/A	0.0011	0.0000334	N/A	0.001	N/A	N/A	0.001
	3000	0.00000052	N/A	0.001	0.000031	N/A	0.001	N/A	N/A	0.001
	3500	0.00000051	N/A	0.001	0.0000326	N/A	N/A	N/A	N/A	0.001
	4000	0.000000498	N/A	N/A	0.000027	N/A	N/A	N/A	N/A	N/A
	4500	0.000000492	N/A	N/A	0.0000304	N/A	N/A	N/A	N/A	N/A
	5000	0.00000048	N/A	N/A	0.0000303	N/A	N/A	N/A	N/A	N/A
	5500	0.00000048	N/A	N/A	0.000019	N/A	N/A	N/A	N/A	N/A
	6000	0.00000047	N/A	N/A	0.000016	N/A	N/A	N/A	N/A	N/A
	"y"	N/A	963	1000	N/A	1063	1250	N/A	871	1250

FSA *m* and *y* Round Robin Test Results (Determination of "*y*" Constant) (cc/min)

		Lab 1 CNA 1	Lab 2 CNA 1	Lab 3 CNA 1	Lab 1 CNA 2	Lab 2 CNA 2	Lab 3 CNA 2	Lab 1 CNA 3	Lab 2 CNA 3	Lab 3 CNA 3
Unit Stress (psi)	0									
	500	0.78	0.1497	0.523	0.834	0.7131	0.8752	N/A	N/A	0.8054
	1000	0.247	0.0844	0.187	0.246	0.11241	0.2845	N/A	N/A	0.2924
	1500	0.1032	0.0337	0.1251	0.104	0.05007	0.1562	N/A	N/A	0.1839
	2000	0.044	0.014	0.0265	0.044	0.02168	0.0182	N/A	N/A	0.0228
	2500	0.01686	0.008	0.0094	0.0168	0.00931	0.0121	N/A	N/A	0.0084
	3000	0.00738	0.0073	0.0081	0.0074	0.00389	0.0049	N/A	N/A	0.0041
	3500	0.003348	0.0049	0.0037	0.0033	N/A	0.0029	N/A	N/A	0.0027
	4000	0.001488	N/A	N/A	0.0015	N/A	N/A	N/A	N/A	N/A
	4500	0.000666	N/A	N/A	0.00067	N/A	N/A	N/A	N/A	N/A
	5000	0.00027	N/A	N/A	0.00027	N/A	N/A	N/A	N/A	N/A
	5500	0.000102	N/A	N/A	0.0001	N/A	N/A	N/A	N/A	N/A
	6000	0.000054	N/A	N/A	0.000057	N/A	N/A	N/A	N/A	N/A
	"m"	3250	3205	3250	3250	2787	3000	N/A	N/A	2750

FSA *m* and *y* Round Robin Test Results (Determination of "*m*" Constant) (cc/min)

		Lab 1 PTFE 1	Lab 2 PTFE 1	Lab 3 PTFE 1	Lab 1 PTFE 2	Lab 2 PTFE 2	Lab 3 PTFE 2	Lab 1 PTFE 3	Lab 2 PTFE 3	Lab 3 PTFE 3
Unit Stress (psi)	6770	0.0000015	N/A	N/A	0.000021	N/A	N/A	N/A	N/A	N/A
	6270	0.0000062	N/A	N/A	0.000033	N/A	N/A	N/A	N/A	N/A
	5770	0.000069	N/A	N/A	0.00017	N/A	N/A	N/A	N/A	N/A
	5270	0.00023	0.013	0.00015	0.00053	0.004	0.0018	N/A	0.048	0.0025
	4770	0.0005	0.008	0.00129	0.000978	0.005	0.00452	N/A	0.055	0.0039
	4270	0.00082	0.008	0.0027	0.001506	0.007	0.00651	N/A	0.03	0.0045
	3770	0.0012	0.01	0.002	0.002106	0.004	0.0082	N/A	0.028	0.009
	3270	0.0016	0.011	0.0034	0.002856	0.006	0.009	N/A	0.042	0.0101
	2770	0.0022	0.01	0.0048	0.003768	0.005	0.0124	N/A	0.045	0.0185
	2270	0.0032	0.014	0.0087	0.00512	0.006	0.0158	N/A	0.067	0.0379
	1770	0.0052	0.016	0.0179	0.00846	0.01	0.026	N/A	0.082	0.059
	1270	0.0519	0.021	0.0255	0.0064	0.016	0.0364	N/A	0.136	0.0812
	770	0.078	0.045	0.092	3.24	0.037	0.077	N/A	0.356	0.095
	"m"							N/A		

FSA *m* and *Y* Round Robin Test Results (Determination of "*m*" Constant) (cc/min)

		Lab 1 CNA 1	Lab 2 CNA 1	Lab 3 CNA 1	Lab 1 CNA 2	Lab 2 CNA 2	Lab 3 CNA 2	Lab 1 CNA 3	Lab 2 CNA 3	Lab 3 CNA 3
Unit Stress (psi)	6770	0.002	0.123	0.0041	0.058	N/A	0.0062	N/A	N/A	0.0018
	6270	0.002	0.129	0.0081	0.06	0.006	0.0088	N/A	N/A	0.002
	5770	0.002	0.134	0.0082	0.064	0.007	0.0099	N/A	N/A	0.0029
	5270	0.002	0.141	0.0194	0.07	0.005	0.018	N/A	N/A	0.0356
	4770	0.002	0.143	0.0572	0.074	0.008	0.0196	N/A	N/A	0.0893
	4270	0.002	0.147	0.0852	0.079	0.008	0.0363	N/A	N/A	0.1837
	3770	0.002	0.149	0.381	0.086	0.005	0.1655	N/A	N/A	0.3832
	3270	0.002	0.165	0.519	0.092	0.007	0.448	N/A	N/A	0.4894
	2770	0.002	0.175	0.873	0.101	0.009	0.5941	N/A	N/A	0.6068
	2270	0.003	0.2	1.294	0.115	0.012	0.9191	N/A	N/A	0.8429
	1770	0.005	0.246	N/A	0.135	0.017	N/A	N/A	N/A	N/A
	1270	0.035	0.363	N/A	0.184	0.043	N/A	N/A	N/A	N/A
	770	1.98	0.671	N/A	1.056	0.199	N/A	N/A	N/A	N/A
	"m"			3270			3270	N/A	N/A	3270

FSA *m* and *y* Round Robin Test Results (Determination of "*y*" Constant) cc/min/inch OD

		Lab 1 PTFE 1	Lab 2 PTFE 1	Lab 3 PTFE 1	Lab 1 PTFE 2	Lab 2 PTFE 2	Lab 3 PTFE 2	Lab 1 PTFE 3	Lab 2 PTFE 3	Lab 3 PTFE 3
Unit Stress (psi)	0									
	500	0.000114286	0.009517	0.01268174	0.00051429	0.0043	0.00408724	N/A	0.01322333	0.01455574
	1000	5.14286E-06	0.00109617	0.00092084	6.2857E-05	0.00068333	0.00140549	N/A	0.00032	0.00127625
	1500	1.71429E-07		0.00067851	9.8571E-06		0.00069467	N/A		0.00063005
	2000	1.62857E-07		0.00054927	9.6857E-06		0.00075929	N/A		0.00035541
	2500	1.51429E-07		0.00017771	9.5429E-06		0.00016155	N/A		0.00016155
	3000	1.48571E-07		0.00016155	8.8571E-06		0.00016155	N/A		0.00016155
	3500	1.45714E-07		0.00016155	9.3143E-06			N/A		0.00016155
	4000	1.42286E-07			7.7143E-06			N/A		
	4500	1.40571E-07			8.6857E-06			N/A		
	5000	1.37143E-07			8.6571E-06			N/A		
	5500	1.37143E-07			5.4286E-06			N/A		
	6000	1.34286E-07			4.5714E-06			N/A		
	"y"	500	1000	1000	500	1000	1000	N/A	1000	1000

FSA *m* and *y* Round Robin Test Results (Determination of "*y*" Constant) cc/min/inch OD

		Lab 1 CNA 1	Lab 2 CNA 1	Lab 3 CNA 1	Lab 1 CNA 2	Lab 2 CNA 2	Lab 3 CNA 2	Lab 1 CNA 3	Lab 2 CNA 3	Lab 3 CNA 3
Unit Stress (psi)	0									
	500	0.222857143	0.02495	0.08449111	0.23828571	0.11885	0.14138934	N/A		0.13011309
	1000	0.070571429	0.01406667	0.03021002	0.07028571	0.018735	0.04596123	N/A		0.04723748
	1500	0.029485714	0.00561667	0.02021002	0.02971429	0.008345	0.02523425	N/A		0.02970921
	2000	0.012571429	0.00233333	0.0042811	0.01257143	0.00361333	0.00294023	N/A		0.00368336
	2500	0.004817143	0.00133333	0.00151858	0.0048	0.00155167	0.00195477	N/A		0.00135703
	3000	0.002108571	0.00121667	0.00130856	0.00211429	0.00064833	0.0007916	N/A		0.00066236
	3500	0.000956571	0.00081667	0.00059774	0.00094286		0.0004685	N/A		0.00043619
	4000	0.000425143			0.00042857			N/A		
	4500	0.000190286			0.00019143			N/A		
	5000	7.71429E-05			7.7143E-05			N/A		
	5500	2.91429E-05			2.8571E-05			N/A		
	6000	1.54286E-05			1.6286E-05			N/A		
	"y"	3500	3500	3500	3500	3000	3000	N/A		3000

FSA *m* and *y*Round Robin Test Results (Determination of "*m*" Constant) (cc/min/in OD) *

		Lab 1 PTFE 1	Lab 2 PTFE 1	Lab 3 PTFE 1	Lab 1 PTFE 2	Lab 2 PTFE 2	Lab 3 PTFE 2	Lab 1 PTFE 3	Lab 2 PTFE 3	Lab 3 PTFE 3
Unit Stress (psi)	6770	4.28571E-07			0.000006					
	6270	1.77143E-06			9.4286E-06					
	5770	1.97143E-05			4.8571E-05					
	5270	6.57143E-05	0.00216667	2.4233E-05	0.00015143	0.00066667	0.00029079		0.008	0.00040388
	4770	0.000142857	0.00133333	0.0002084	0.00027943	0.00083333	0.00073021		0.00916667	0.00063005
	4270	0.000234286	0.00133333	0.00043619	0.00043029	0.00116667	0.0010517		0.005	0.00072698
	3770	0.000342857	0.00166667	0.0003231	0.00060171	0.00066667	0.00132472		0.00466667	0.00145396
	3270	0.000457143	0.00183333	0.00054927	0.000816	0.001	0.00145396		0.007	0.00163166
	2770	0.000628571	0.00166667	0.00077544	0.00107657	0.00083333	0.00200323		0.0075	0.00298869
	2270	0.000914286	0.00233333	0.00140549	0.00146286	0.001	0.0025525		0.01116667	0.00612278
	1770	0.001485714	0.00266667	0.00289176	0.00241714	0.00166667	0.00420032		0.01366667	0.0095315
	1270	0.014828571	0.0035	0.00411955	0.00182857	0.00266667	0.00588045		0.02266667	0.01311793
	770	0.022285714	0.0075	0.01486268	0.92571429	0.00616667	0.01243942		0.05933333	0.01534733
	"m"	1.5	2.6	1.4	3.2	2.6	1.4	N/A	2.6	1.4

* Note: Lab 2 loads are increased to compensate for end load so the steps are not at same loads

FSA *m* and *y* Round Robin Test Results (Determination of "*m*" Constant) (cc/min/in OD) *

		Lab 1 CNA 1	Lab 2 CNA 1	Lab 3 CNA 1	Lab 1 CNA 2	Lab 2 CNA 2	Lab 3 CNA 2	Lab 1 CNA 3	Lab 2 CNA 3	Lab 3 CNA 3
Unit Stress (psi)	6770	0.000571429	0.0205	0.00066236	0.01657143		0.00100162			0.00029079
	6270	0.000571429	0.0215	0.00130856	0.01714286	0.001	0.00142165			0.0003231
	5770	0.000571429	0.02233333	0.00132472	0.01828571	0.00116667	0.00159935			0.0004685
	5270	0.000571429	0.0235	0.00313409	0.02	0.00083333	0.00290792			0.00575121
	4770	0.000571429	0.02383333	0.00924071	0.02114286	0.00133333	0.0031664			0.01442649
	4270	0.000571429	0.0245	0.01376414	0.02257143	0.00133333	0.0058643			0.0296769
	3770	0.000571429	0.02483333	0.06155089	0.02457143	0.00083333	0.02673667			0.0619063
	3270	0.000571429	0.0275	0.08384491	0.02628571	0.00116667	0.0723748			0.079063
	2770	0.000571429	0.02916667	0.14103393	0.02885714	0.0015	0.09597738			0.09802908
	2270	0.000857143	0.03333333	0.20904685	0.03285714	0.002	0.14848142			0.13617124
	1770	0.001428571	0.041		0.03857143	0.00283333				
	1270	0.01	0.0605		0.05257143	0.00716667				
	770	0.565714286	0.11183333		0.30171429	0.03316667				
	"m"	3.2	2.6	9.8	3.2	2.6	8.1	N/A		8.1

* Note: Lab 2 loads are increased to compensate for end load so the steps are not at same loads