Exova
2395 Speakman Dr.
Mississauga
Ontario
Canada
L5K 1B3

T: +1 (905) 822-4111
F: +1 (905) 823-1446
E: sales@exova.com
W: www.exova.com

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Physical Testing on Adjustment Ring Samples

A Report to:	**Ipex Management Inc.** 2441 Royal Windsor Drive Mississauga, Ontario L5J 4C7
Attention:	**Mr. Gaetano Altomare** **Market Development Manager**
Telephone: E-mail:	905-403-0264 ext. 556 gaetano.altomare@ipexna.com
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1.0 INTRODUCTION

At the request of Ipex Management Inc. (Ipex), Exova performed Physical Testing on Adjustment Ring samples, according with specifications provided by the client.

Ipex submitted three (3) full size adjustment ring specimens for testing. Nine samples of 12 in length were cut off from the full size specimens and allocated with Exova Sample Numbers below:

Exova Sample #	Samples Description
13-06-C0157-1 to 9	Samples of 12 in (304.80 mm) length, 4.875 in (123.82 mm) depth and 1.9685 in (50 mm) thickness

2.0 OBJECTIVES

The objective of the proposed work was to provide information needed to evaluate the properties of the adjustment ring samples, when subjected to a series of compression load applications.

3.0 INSTRUMENTATION

The following instruments were used to measure and record the load values:

10 Kip load cell	MII # B06835
MTS 407 signal conditioner	MII # B06081
Environmental chamber	MII # B04271
Temperature probe	MII # B07887
Calibrated caliper	MII # B00095

4.0 TEST PROCEDURE

The compression test set-up was designed using a servo-hydraulic actuator and a calibrated load cell installed in vertical orientation on a super structure. Each sample was seated on the bottom steel plate which was placed on the test bed and the compression load was applied using an additional steel plate attached to the load cell (support and loading fixtures designed and fabricated by Exova).

The photos of the compression test set-up are presented in Figures 1 to 3.

Three samples were tested at three different temperatures as described in Table 1 below.

Table 1: Environmental Test Conditions

Sample Number	Pre-test Temperature Conditioning (˚C)
13-06-C0157-1 to 3	+ 23
13-06-C0157-4 to 6	- 20
13-06-C0157-7 to 9	+ 30

Prior compression load application each sample was maintained in the environmental at the specified test temperatures for a period of minimum two (2) hours. The compression test was started within one (1) minute after sample removal from environmental chamber.

The photo with example of one batch of samples into the environmental chamber and the shape of the mini specimens are presented in Figures 4 and 5.

The test was performed using smaller samples cut off from full size adjustment ring specimens. The required compression loads were calculated based on full load design of 166.6 KN (for a full size specimen) to develop the same stress on the smaller size samples as explained below.

- Full size specimen area Af = 558.1875 sq-in
- Load bearing surface area of the mini specimens Ams = 58.5 sq-in
- Initial stress on the adjustment unit Si = 14 KN/Af = 38.8541 KPa
- Final stress on the adjustment unit Sf = 166.6 KN/Af = 462.3632 KPa
- Initial load on the mini specimens Lmi = Si x Ams = 1,466.95 N (329.8 lbs)
- Final load on the mini specimens Lmf = Sf x Ams = 17,458.84 N (3,925.1 lbs)

The compression load test sequence, measurements and calculations are described below.

- Measure sample thickness at four locations prior compression and calculate average Do
- Apply initial constant load Lmi = 1,466.95 N, measure the thickness of the sample at the same four locations and calculate initial thickness of the sample prior compression D1
- Apply final load Lmf = 17,458.84 N in 20 seconds (using a ramp rate of 800 N/sec), measure the thickness of the sample at the same four locations and calculate initial compression deformation of the sample D2
- Calculate the initial compression deformation Cd1 = D1 – D2
- Maintain final load Lmf for a period of 30 minutes then measure the thickness of the sample at the same four locations and calculate the average final compression deformation thickness D3
- Calculate average final compression deformation Cd2 = D1 – D3
- Remove the load and allow the sample to rest undisturbed for a period of 30 minutes
- Apply initial constant load Lmi, measure the thickness of the sample at the same four locations and calculate the average compression set thickness D4
- Calculate average compression set Cs = D1 – D4
- Calculate average initial compression deformation = (Cd1/D1)*100 (%)
- Calculate average final compression deformation = (Cd2/D1)*100 (%)
- Calculate allowable average compression set = (Cs/D1)*100 (%)

Maximum allowable percentage compression deformation and compression set for each sample are presented in Table 2 below.

Table 2: Maximum Allowable Compression Deformation and Compression Set

Pre-test Temperature Conditioning (˚C)	Maximum Average Initial Compression Deformation (%)	Maximum Average Final Compression Deformation (%)	Maximum Allowable Average Compression Set (%)
+ 30	3.3	7.4	1.3
+ 23	1.9	3.0	0.8
- 20	1.1	0.8	0.5

5.0 RESULTS

The calculated deflections for each sample/temperature condition are presented in the Tables 3 to 5 below.

Table 3: Results for + 23˚C Test Samples

Description of Measured/Calculated Thickness	Sample Number		
	13-06-C0157-1	13-06-C0157-2	13-06-C0157-3
Initial average sample thickness Do (mm)	49.76	49.51	49.51
Sample average thickness prior compression D1 (mm)	49.63	49.39	49.37
Initial average compression deformation thickness D2 (mm)	49.36	49.13	49.12
Initial compression deformation Cd1 (mm)	0.27	0.26	0.25
Final average compression deformation thickness D3 (mm)	49.31	49.06	49.05
Final compression deformation Cd2 (mm)	0.32	0.33	0.32
Average compression set thickness D4 (mm)	49.55	49.31	49.24
Average compression set Cs (mm)	0.08	0.08	0.13
Average initial compression deformation (%)	0.54	0.53	0.51
Average final compression deformation (%)	0.64	0.67	0.65
Allowable average compression set (%)	0.16	0.16	0.26

Table 4: Results for - 20˚C Test Samples

Description of Measured/Calculated Thickness	Sample Number		
	13-06-C0157-4	13-06-C0157-5	13-06-C0157-6
Initial average sample thickness Do (mm)	49.60	49.55	49.49
Sample average thickness prior compression D1 (mm)	49.45	49.40	49.35
Initial average compression deformation thickness D2 (mm)	49.27	49.20	49.17
Initial compression deformation Cd1 (mm)	0.18	0.20	0.18
Final average compression deformation thickness D3 (mm)	49.22	49.15	49.12
Final compression deformation Cd2 (mm)	0.23	0.25	0.23
Average compression set thickness D4 (mm)	49.40	49.34	49.29
Average compression set Cs (mm)	0.05	0.06	0.06
Average initial compression deformation (%)	0.36	0.40	0.36
Average final compression deformation (%)	0.46	0.51	0.47
Allowable average compression set (%)	0.10	0.12	0.12