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BRE Global Test Report

Ad-hoc fire resistance test on a galvanised steel Tunnel Ventilation Damper employing procedures and criteria from BS 476: Part 20 : 1987.

Prepared for: **Betec Cad Industries**

Date: **16/09/2015**

Report Number: **302276 Issue: 1**

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Summary

An ad-hoc fire resistance test, following the furnace heating conditions given in BS 476: Part 20: 1987[1], was carried out on a galvanised steel Tunnel Ventilation Damper, installed on the unexposed face of a 200mm thick concrete slab floor, on 2nd June 2015 for a duration of 189 minutes.

The test was conducted at the request of Betec Cad Industries, at BRE Laboratories, Garston and employed procedures and criteria from BS 476: Part 20: 1987[1]. The pressure conditions within the furnace were maintained to give 20Pa at the level of the damper blades.

As the damper was uninsulated, no thermocouples were attached to the damper casing or spigot. However, the approximate insulation performance of the damper was assessed using a roving thermocouple.

For the criteria adopted, the damper achieved the following fire resistance:

Integrity	Insulation
174 mins	<5 mins

The test was not conducted under the requirements of UKAS accreditation.

The information presented in this report should not be used to demonstrate performance against any standard nor compliance with a regulatory requirement. This report covers a test which was conducted to a procedure which is not the subject of any British Standard specification, but the test utilised the general principles of fire resistance testing given in BS 476: Part 20: 1987[1].

1 Objective

An ad-hoc fire resistance test was carried out to the basic principles of BS 476: Part 20: 1987[1], at the request of Betec Cad Industries, to determine the performance of a horizontally mounted, galvanised steel Tunnel Ventilation Damper in a 200mm-thick aerated concrete floor.

2 Test construction

The test specimen comprised one multi-blade damper, nominally 1015mm-wide x 1215mm-high x 500mm-deep. The damper was installed above an aperture (nominally 1000mm x 1200mm) created near the centre of a 3m x 2.5m x 0.2m floor. The floor surrounding the damper (and to which it was attached) was formed from aerated concrete blocks. The damper was fixed to the unexposed face of the floor with 24 masonry screws (7.5mmx40mm, 6 per side) and four M10 studs (one per corner) which passed through the damper mounting flange. The M12 studs passed though the concrete floor and into the furnace, before being secured with a nut and washer on each side.

The damper comprised six galvanised steel rotating blades, each blade nominally 185mm wide x 905mm long, contained within a galvanised steel frame. The blades were formed from a double skin of 2mm-thick galvanised steel, and included a thin stainless steel strip, protruding from each edge of the blade by approximately 6mm. Each blade was held together with 18 rivets, and was attached to an axle at each end. The third blade from the top of the damper was attached to a 24mm-diameter solid steel rod, which connected to the actuator. Further details of the damper are given in the drawings in the *Figures* section of this report, and are also kept on file.

The actuator was an electrically triggered, pneumatically operated type, observed to be a “Hytork 131” actuator. A data sheet for the actuator is attached in the *Figures* section of this report.

The damper and actuator are shown before and after the test in *Photographs*.

3 Test procedure

3.1 General

The test was conducted using the furnace heating conditions defined within ISO834-1[2], and employed appropriate procedures from BS 476: Part 20: 1987[1] on 2nd June 2015.

The test was conducted using a 4m-long x 2.5m-wide x 2m-high furnace at BRE Laboratories, Garston and witnessed by Mr Sriram (representing the sponsor Betec Cad Industries).

The ambient temperature at the start of the test was 17°C.

3.2 Furnace control

The furnace temperature was controlled by means of six bare-wire thermocouples, distributed evenly across the centre of the furnace (nominally 1000mm centres), arranged in two rows of three thermocouples (nominally 500mm spacing between rows and 100mm below the soffit of the concrete floor).

The furnace was controlled so that the average temperature followed the time / temperature relationship specified within BS 476: Part 20: 1987[1]. The mean furnace temperature is plotted against time in *Graphs*, together with the specified temperature curve for comparison.

The target furnace pressure, at a point 300mm below the soffit of the concrete slab, was 14Pa above the laboratory pressure. This produced a pressure equivalent to 20Pa above the laboratory pressure at the level of the damper blades.

3.3 Actuation of steel damper

As there was no thermal fuse supplied with the damper and actuator, the damper was manually triggered to close after 30 seconds of the start of the test. The complete procedure was as follows:

- Prior to test start: Pneumatic system supplied with 3 bar pressure. Damper open.
- 30 seconds into test: Actuator supplied with power. Damper closed.
- 30 seconds – test end: Pressure supply removed. Power supply removed. Damper remained closed.

3.4 Measurement of steel temperatures

As the damper was un-insulated, no thermocouples were attached to the damper casing or spigot. However, the approximate insulation performance of the damper was assessed using a roving thermocouple in the following locations:

1) Centre of galvanised steel casing (Side 1), approximately 100mm above the concrete floor.
2) Centre of 3rd damper blade (referenced ‘c’ in Figure 1).
3) Centre of ‘shelf’ (Side 3) surrounding damper blades.
4) Centre of galvanised steel casing (Side 3), approximately 100mm above the concrete floor.

4 Results

4.1 Observations

The observations made during the test are given in Table 1 and are with reference to Figure 1.

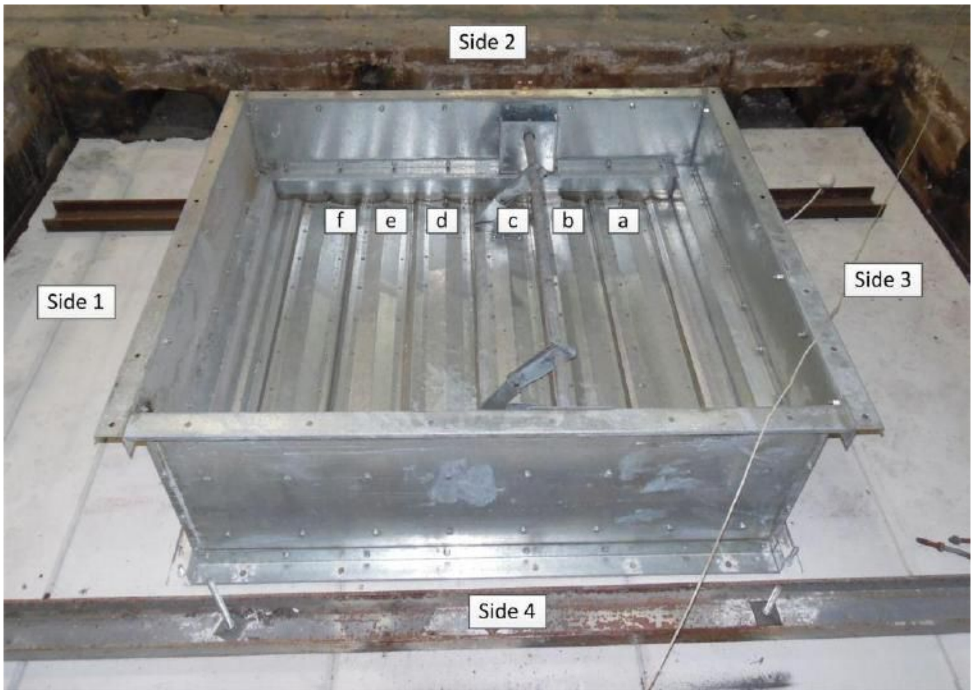


Figure 1: Labelled diagram of damper for reference purposes.

Time (mins:secs)	Observations
00:00	Test started. Damper open.
00:30	Power supply connected, damper closed. Pressure supply disconnected, power supply disconnected, damper remains closed.
05:30	Roving thermocouple measurements: Location 1: 120ºC Location 2: 260ºC Location 3: 95ºC
12:00	A vertical gap of approximately 10mm has formed between the outermost blades (a and f) and the damper edge. 6mm gap gauge can slide a distance of 250mm between blades but only enters 10mm due to metal lip.
20:30	Spoiling of metal (white discolouration) surrounding the bolts fixing the damper to the concrete slab.

Time (mins:secs)	Observations
24:00	Roving thermocouple measurements: Location 1: 275ºC Location 2: 440ºC Location 3: 200ºC Location 4: 225ºC Expansion of gap at the outermost damper blades to 20mm. Separation of 15mm between blades a-b and blades b-c. 6mm gap gauge does not penetrate into the furnace.
29:00	Charring to the tips of the damper blades.
34:00	Roving thermocouple measurements: Location 1: 310ºC Location 2: n/a – heat damage to thermocouple casing. Location 3: 225ºC Location 4: 340ºC Glowing steel between bolts on the damper casing near to the attachment to the concrete floor. Yellow discolouration at the tips of the damper blades.
57:00	Roving thermocouple measurements: Location 1: n/a – heat damage to thermocouple casing. Location 2: n/a – heat damage to thermocouple casing. Location 3: 300ºC Location 4: n/a – heat damage to thermocouple casing. Area of glowing steel extends approximately 60mm above the concrete slab. 5mm separation of the steel casing at the mid-point between rivets. Discolouration of the steel casing extends nominally 250mm above the concrete floor.
88:00	6mm gap gauge penetrates 50mm underneath damper blade ‘a’ but does not penetrate into the furnace.
120:00	Area of glowing steel now extends 100mm above the concrete slab. No significant change with regards to the damper blade separation.
150:00	No significant visual change.
174:00	Intensity of glowing steel has increased to a dark red colour. Delamination of steel beginning to occur. 25mm gap gauge can be inserted between damper blade ‘a’ and the damper edge into the furnace. 6mm gap gauge can penetrate to the same depth along 75% (700mm) of the damper blades length. Failure of integrity.
189:00	Test terminated.

Table 1: Observations.

5 Performance criteria

The criteria for failure under integrity and insulation as specified in BS 476: Part 20: 1987[1] are given below. In the absence of a specific test for damper systems, the same criteria were used except where stated.

Integrity
A failure of the test construction to maintain integrity shall be deemed to have occurred when collapse or sustained flaming on the unexposed face occurs or when one or other of the following conditions prevail:

*Cotton pad	when cracks, gaps or fissures allow flames or hot gases to cause flaming or glowing of a cotton fibre pad.
Gap gauges	when a 25mm-diameter gap gauge can penetrate through a gap into the furnace; or when a 6mm-diameter gap gauge can penetrate through a gap into the furnace and be moved in the gap for a distance of at least 150mm.

Insulation

Failure is deemed to have occurred when one of the following occurs:

a)**when the mean unexposed face temperature increases by more than 140°C above its initial value;

b) when the temperature recorded at any position on the unexposed face is in excess of 180°C above the initial mean unexposed face temperature;

c) when integrity failure occurs

* The cotton pad test was not considered applicable to a test of this nature.

** The mean temperature rise was not considered applicable as no fixed thermocouples were applied to the sample.

6 Conclusion

An ad-hoc fire resistance test was carried out, following the furnace heating conditions given in BS 476: Part 20: 1987[1], for a duration of 189 minutes, on a galvanised steel Tunnel Ventilation Damper, installed on the unexposed face of a concrete block floor, as described in this report.

This report covers a test which was conducted to a procedure which is not the subject of any British Standard specification, but the test utilised the general principles of fire resistance testing given in BS 476: Part 20: 1987.

For the criteria adopted the damper achieved the following fire resistance (reported as the last completed minute before failure):

Integrity	Insulation
174mins	<5mins

This report provides the constructional details, the test conditions and the results obtained when a specific element of construction was tested following the procedure specified in BS 476: Part 20: 1987. Any significant deviation with respect to size, constructional details, loads, stresses, edge or end conditions may invalidate the test results.

7 Limitations

The test was not conducted under the requirements of UKAS accreditation.

The information presented in this report should not be used to demonstrate performance against any standard nor compliance with a regulatory requirement. This report covers a test which was conducted to a procedure which is not the subject of any British Standard specification, but the test utilised the general principles of fire resistance testing given in BS 476: Part 20: 1987.

The results only relate to the behaviour of the specimen of the element of construction under the particular conditions of test; they are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they reflect the actual behaviour in fires.

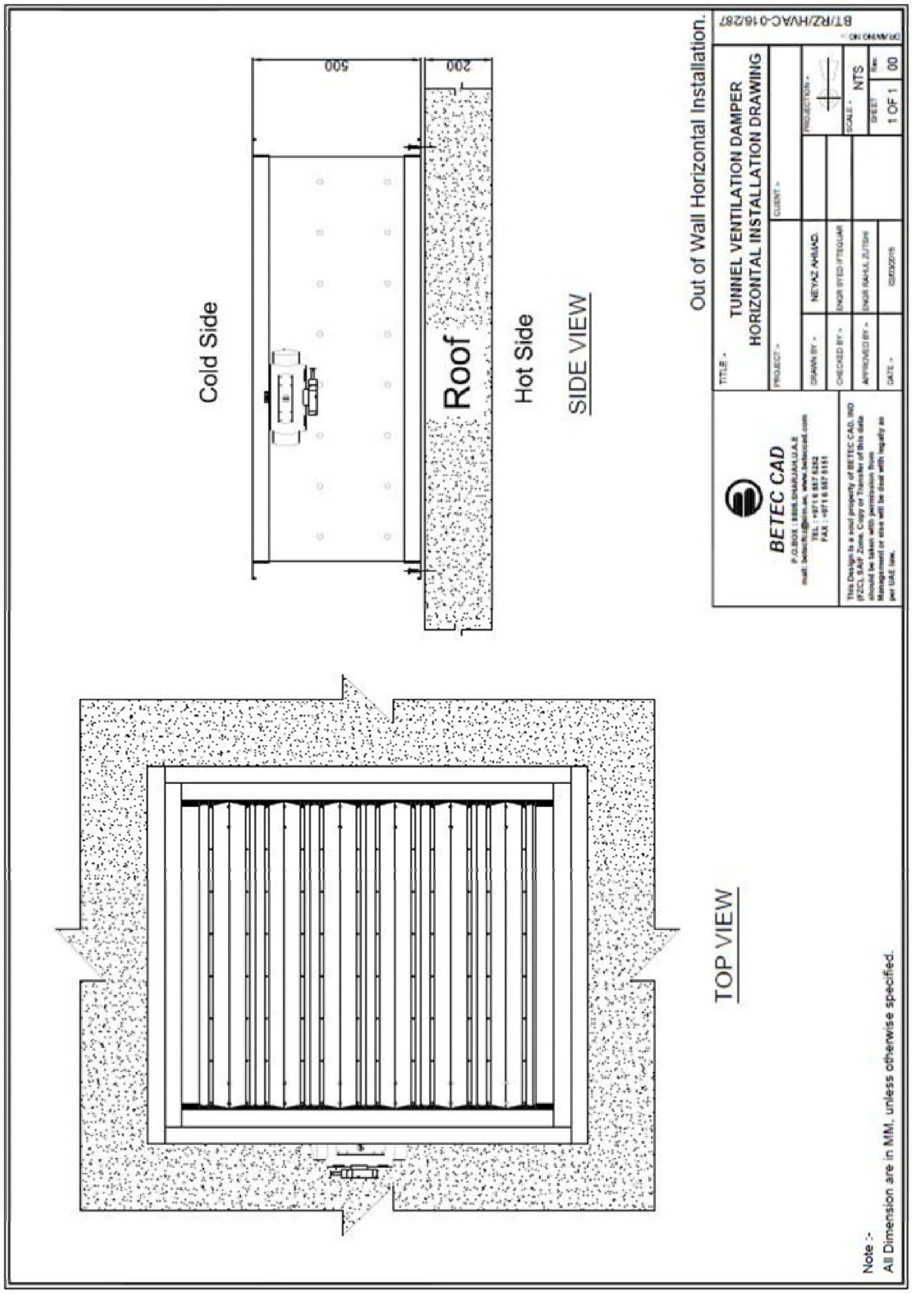
Because of the nature of fire resistance testing and the consequent difficulty in quantifying the uncertainty of measurement of fire resistance, it is not possible to provide a stated degree of accuracy of the result.

The specification and interpretation of fire test methods is the subject of on-going development and refinement. Changes in associated legislation may also occur. For these reasons it is recommended that the relevance of test reports over 5 years old should be considered by the user. The laboratory that issued the report will be able to offer, on behalf of the legal owner, a review of the procedures adopted for a particular test to ensure that they are consistent with current practices, and if required may endorse the test report.

8 References

1. Fire tests on building materials and structures. Part 20. Method for determination of the fire resistance of elements of construction (general principles). British Standard 476: Part 20:1987 (inc. Amendment 1:1990). British Standards Institution, London, 1990.
2. Fire-resistance tests – Elements of building construction. Part 1: General requirements. ISO 834-1: Part 1: 1999. International Organization for Standardization, Switzerland, 1999.

9 Figures


Out of Wall Horizontal Installation.
TUNNEL VENTILATION DAMPER
HORIZONTAL INSTALLATION DRAWING
BETEC CAD
NEYAZ AHMAD
NTS
1 OF 1
00
BT/RZ/HVAC-0-16/287
Cold Side
Roof
Hot Side
SIDE VIEW
500
200
TOP VIEW
Note :-
All Dimension are in MM, unless otherwise specified.

Hytork "TA" Tunnel Applications actuator

For use in conjunction with Tunnel Transit Damper which exceeds a test to operate safely at 250°/482°F for a minimum of two hours

"Tunnel Applications"

In modern traffic tunnels the venting system that removes or blocks toxic gasses and blinding smoke, is required to function in support of a safety window in time and operate for a number of cycles, both during and after a fire.

During such a fire, relative high temperatures may be reached around the venting system and systems must have the ability to continue operating during this critical safety window. These venting systems combine a louvred damper driven by a pneumatic actuator that vents or blocks the air flow in a tunnel and is constructed to operate safely at temperatures of up to 250°C ~ 482°F for a minimum of two hours.

The Hytork TA Solution

Emerson has developed a Hytork brand spring return actuator for these kinds of high demanding "Tunnel Applications" that can cope with these requirements. The actuator is equipped with special seals, bearings and grease to accommodate these temperatures.

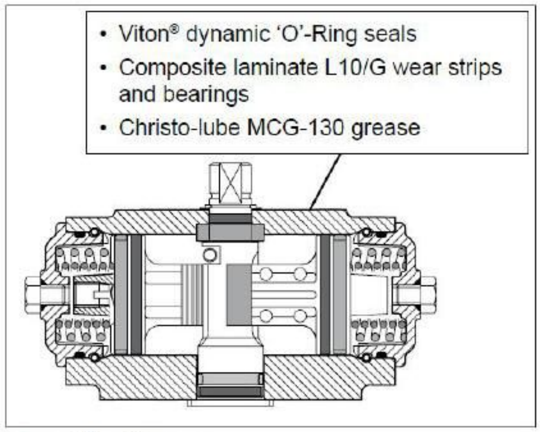
Under normal conditions the actuator functions as a normal Spring Return actuator, and in the case of a fire the actuator will be able to function a number of times under the below mentioned conditions.

Conformance Test Procedure:

Test actuators have been subjected to a specific high temperature / functional test as follows;

Step	Description
1.	Measure Torque output before test.
2.	Actuator put in oven, which is already at 250°C/ 482°F.
3.	Cycle Actuator at beginning of 2 hour period.
4.	Cycle Actuator every 15 minutes in oven at 250°C/ 482°F.
5.	Cycle Actuator several times at end of 2 hour period.
6.	Measure Torque output After test.

The test report is available on request.



Specifications:

Temperature range

Normal operation	: -20°C to +120°C
(No fire)	: -4°F to + 248°F
Tunnel Application	: -20°C to +250°C
(Under fire)	for 2 hours minimum
	: -4°F to / +482°F
	for 2 hours minimum
Dynamic O-ring seals	: Fluorocarbon Rubber 9775 (Viton®).
Static O-ring seals	: Nitrile Rubber (Buna-N)
Bearing material	: High temperature composite laminate L10/G
Grease	: Christo-lube MCG-130

High temperature effects on output torque.

Spring stroke

Due to the high temperatures occurring during a fire, the spring torque will reduce due to the annealing affect of the heat, causing a drop in output torque of about 10% on the spring stroke. The attached torque table reflects the torque output of a standard actuator with 10% torque loss on the spring stroke after a fire.

Air stroke

The table shows also the torque output of the air stroke. Note that these torque values are in some cases much higher (compared to a standard actuator) depending on the supply pressure and the chosen spring set.

Sizing instructions

To select the right size of the actuator for a tunnel application two things have to be checked:

1 Sizing

a Choose the smallest actuator size for **normal operation (no fire)**. Use the torque figures as per data sheet

Imperial data D67 (see web site).

Metric data D66 (see web site).

b Choose the smallest actuator size **operation under fire.** Use the attached output torque table on page 3 and 4.

Use normal sizing procedure to define smallest actuator. Note that the air stroke torque output values are always higher than the spring torque values.

c Select the largest actuator from "a" or "b".

Note;

We recommend that the valve (or louver) manufacturer supplies the maximum required torque values, including any adjustments or suggested safety factors for valve or louver service conditions or application.

Additionally, the valve manufacturer must identify at which position(s) and direction(s) of rotation (Counter Clock Wise or Clock Wise) these maximum requirements occur.

2 Check the maximum valve stem torque

Check the maximum valve stem torque for the chosen smallest actuator size. The maximum valve stem torque should be lower than the output torque on the air stroke.

For venting louvres, the drive mechanism should be capable to cope with the maximum air stroke torque output torque of the chosen actuator.

Important: Use the maximum available plant pressure to define the maximum torque output on the air stroke of the actuator.

High temperature effects on actuator components

A high temperature operation as indicated under "Test Procedure" has influence on the:

- Springs; spring forces decreased.
- Grease; will dry out and might get hard.
- Soft parts; will lose their original shape and or strength.

Therefore we strongly recommend replacing the actuator after a high temperature operation as indicated under "Conformance Test Procedure".

WARNING : Use only Spring Return (fail safe) models – Do not use Double Acting models, where the air needs to be driven in both directions.

At high temperatures of 250°C / 482°F, there is a risk that the plastic head and the rubber 'o' ring of the metal SafeKey could melt. This will cause complete torque loss on the inward stroke of double acting models.

We therefore advise to use only Spring Return models for these "Tunnel Applications".

This problem does not occur on Spring Return models because the end cap chambers on Spring Return are normally not pressurized.

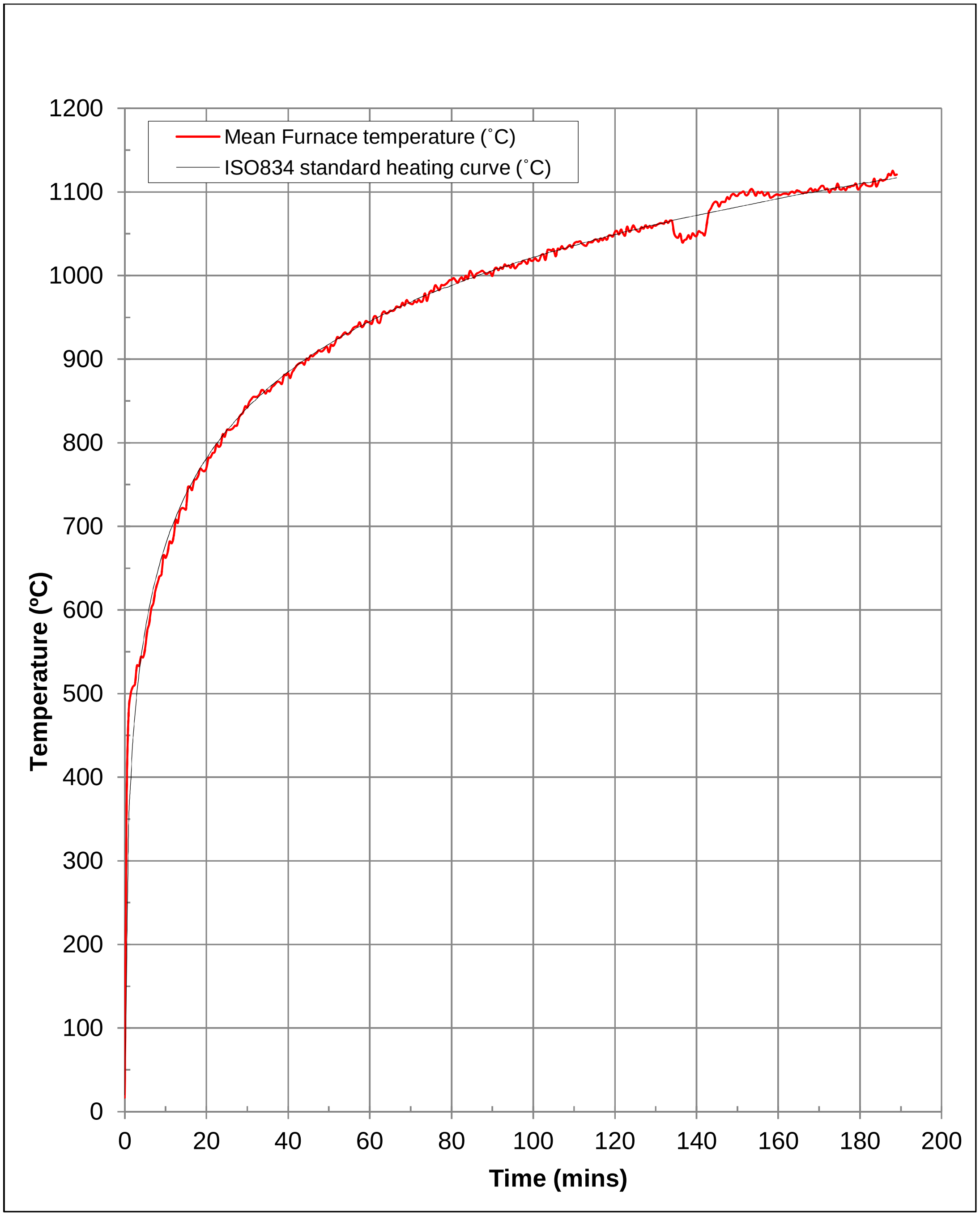
Torque output values for use on Tunnel applications Spring Return Actuators (Nm), XL26 to XL681

Model Number	Spring Rating	Torque from Springs		Torques from air stroke (Nm) at given operating air pressure (bar)													
				3.0 bar(g)		4.0 bar(g)		5.0 bar(g)		5.5 bar(g)		6.0 bar(g)		7.0 bar(g)		8.0 bar(g)	
		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
XL26	S40	5	3	7	5	11	8	14	12	16	14	17	15	21	19	24	22
	S50	7	4	6	4	10	7	13	11	15	12	17	14	20	17	24	21
	S60	8	5	6	2	9	6	12	9	14	11	16	13	19	16	23	20
	S70	9	6	-	-	8	4	12	8	13	10	15	11	18	15	22	18
	S80	11	6	-	-	7	3	11	7	13	8	14	10	18	13	21	17
	S90	12	7	-	-	7	2	10	5	12	7	13	9	17	12	20	16
	S1C	13	8	-	-	-	-	9	4	11	6	13	7	16	11	20	14
XL71	S40	13	8	18	12	26	21	35	30	39	34	44	38	52	47	61	55
	S50	17	10	16	9	24	18	33	26	37	31	42	35	50	44	59	52
	S60	20	12	14	6	22	14	31	23	35	27	40	32	48	40	57	49
	S70	23	14	-	-	20	11	29	20	33	24	38	28	46	37	55	45
	S80	27	16	-	-	18	8	27	16	31	21	36	25	44	34	53	42
	S90	30	18	-	-	16	4	25	13	29	17	34	22	42	30	51	39
	S1C	33	20	-	-	-	-	23	10	27	14	32	18	40	27	49	35
XL131	S40	25	15	33	23	50	40	66	56	74	64	82	72	98	88	114	104
	S50	31	19	30	17	46	33	62	50	70	58	78	66	94	82	111	98
	S60	38	23	26	11	42	27	58	43	66	51	75	59	91	76	107	92
	S70	44	26	-	-	38	21	55	37	63	45	71	53	87	69	103	86
	S80	50	30	-	-	35	15	51	31	59	39	67	47	83	63	99	79
	S90	56	34	-	-	31	8	47	24	55	33	63	41	79	57	96	73
	S1C	63	38	-	-	-	-	43	18	51	26	59	34	76	51	92	67
XL186	S40	34	20	45	32	67	53	89	75	100	86	110	97	132	119	154	140
	S50	42	25	40	23	62	45	84	67	94	78	105	89	127	110	149	132
	S60	50	30	35	15	57	37	79	58	89	69	100	80	122	102	144	124
	S70	59	35	-	-	52	28	74	50	84	61	95	72	117	94	139	115
	S80	67	40	-	-	47	20	68	42	79	52	90	63	112	85	134	107
	S90	76	45	-	-	42	11	63	33	74	44	85	55	107	77	129	98
	S1C	84	50	-	-	-	-	58	25	69	36	80	47	102	68	124	90
XL221	S40	47	28	63	44	93	74	123	105	139	120	154	135	184	165	214	196
	S50	59	35	56	32	86	62	116	93	131	108	147	123	177	153	207	184
	S60	71	42	49	20	79	51	109	81	124	96	140	111	170	142	200	172
	S70	82	49	-	-	72	39	102	69	117	84	133	100	163	130	193	160
	S80	94	56	-	-	65	27	95	58	110	73	125	88	156	118	186	148
	S90	106	63	-	-	58	15	88	46	103	61	118	76	149	106	179	137
	S1C	118	71	-	-	-	-	81	34	96	49	111	64	142	95	172	125
XL281	S40	58	34	75	51	111	87	148	124	166	142	184	160	220	196	256	233
	S50	72	42	67	37	103	73	139	109	157	127	176	146	212	182	248	218
	S60	86	51	58	22	95	59	131	95	149	113	167	131	203	167	240	204
	S70	101	59	-	-	86	44	122	80	141	99	159	117	195	153	231	189
	S80	115	67	-	-	78	30	114	66	132	84	150	102	187	139	223	175
	S90	130	76	-	-	-	-	106	52	124	70	142	88	178	124	214	160
	S1C	144	84	-	-	-	-	97	37	115	55	133	74	170	110	206	146
XL426	S40	85	51	108	74	161	127	214	180	240	206	267	233	320	286	372	339
	S50	106	63	95	53	148	106	201	159	228	185	254	212	307	265	360	318
	S60	127	76	83	32	136	85	188	138	215	164	241	191	294	244	347	296
	S70	148	89	-	-	123	64	176	117	202	143	229	169	282	222	334	275
	S80	169	101	-	-	110	43	163	95	190	122	216	148	269	201	322	254
	S90	190	114	-	-	-	-	150	74	177	101	203	127	256	180	309	233
	S1C	211	127	-	-	-	-	138	53	164	80	191	106	244	159	296	212
XL681	S40	136	82	177	123	263	209	350	295	393	338	436	381	522	468	608	554
	S50	170	102	157	89	243	175	329	261	372	304	415	347	502	434	588	520
	S60	204	122	136	55	223	141	309	227	352	270	395	313	481	400	567	486
	S70	238	143	-	-	202	107	288	193	331	236	375	279	461	366	547	452
	S80	272	163	-	-	182	73	268	159	311	202	354	245	440	332	527	418
	S90	306	183	-	-	-	-	248	125	291	168	334	211	420	298	506	384
	S1C	340	204	-	-	-	-	227	91	270	134	313	178	400	264	486	350

Note;

We recommend that the valve (or louvre) manufacturer supplies the maximum required torque values (Including any adjustments or suggested safety factors for valve or louvre service conditions or application). Additionally, the valve manufacturer must identify at which position(s) and direction(s) of rotation (Counter Clock Wise or Clock Wise) these maximum requirements occur.

10 Graph



Graph 1: Mean furnace temperature versus time. ISO 834 standard heating curve included for comparison.

11 Photographs

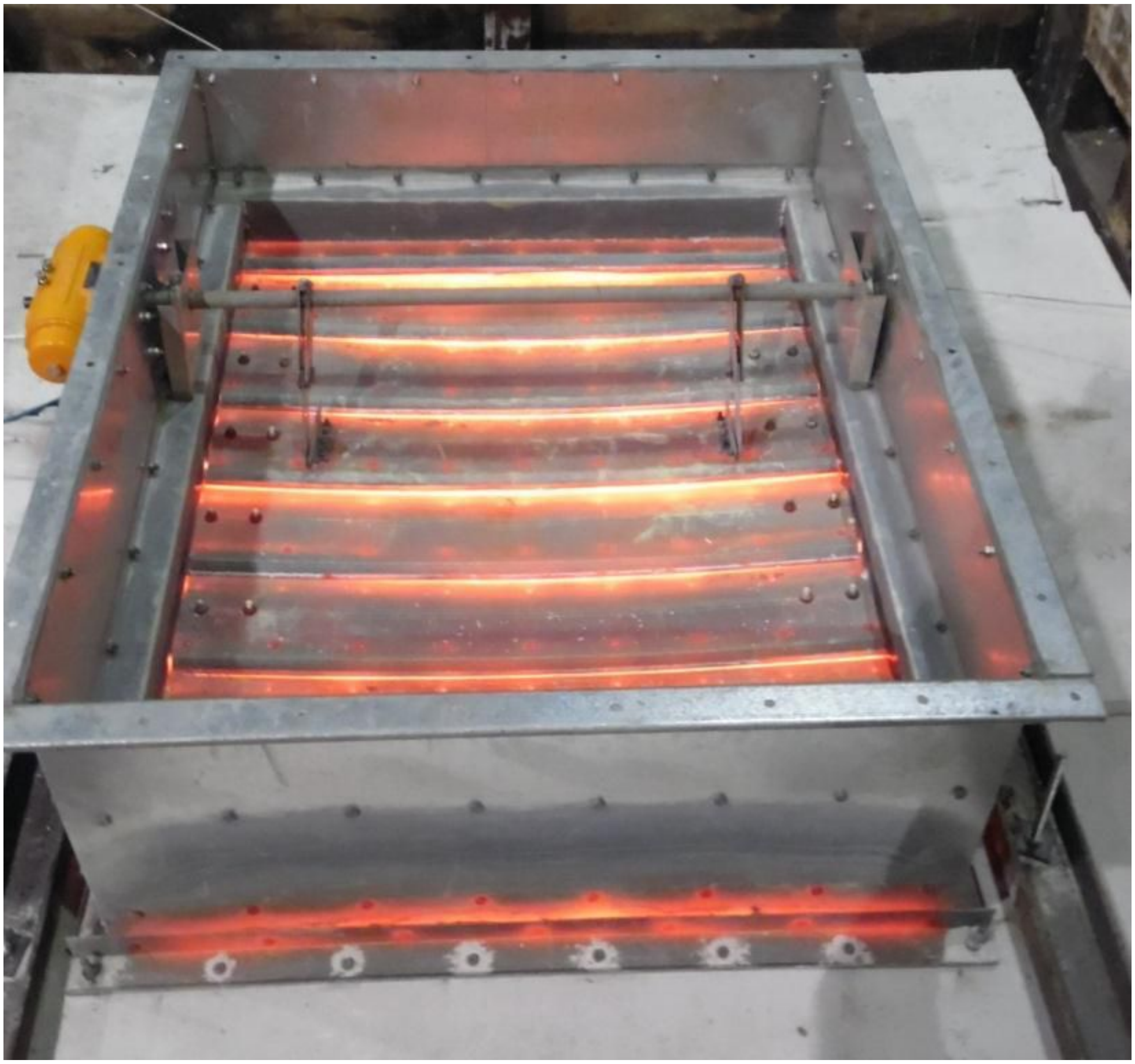
Photograph 1: Exposed face of the damper prior to test (open position).

Photograph 2: Exposed face of the damper prior to test (closed position).

Photograph 3: Exposed face of the damper after test (closed position).

Photograph 4: Unexposed face of the damper prior to test (closed position).

Photograph 5: Unexposed face of the damper after test (closed position).



Photograph 4: Unexposed face of the damper 180 minutes after the start of the test.

Report Ends