Test Report - Commercial in Confidence
V0301-V0304 Marshalls Steel Cores

Test Laboratory	**HORIBA MIRA Ltd**
Date of Report	**20/06/2018**
Client	**Marshalls Street Furniture**
Date of Test	**23/04/2018**
Test Number	**V0301-V0304**
Report Number	**1215709-002-02**
Test Type	**PAS170-1:2017**
Number of Pages	**25**

Prepared By:

Dave Johnstone

Senior Engineer

Approved By:

Rachael Kennedy

Head of Highway Safety & Protection of Infrastructure

Date:20th June 2018

UKAS TESTING 1105

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Contents

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1 Introduction

1.1 Product Manufacturer

Name	Marshalls Street Furniture
Address	Landscape House, Premier Way, Lowfields Business Park, Elland, West Yorkshire, HX5 9HT
Internet address / email	Roger.knight@marshalls.co.uk

1.2 Client

Name	Marshalls Street Furniture	
Address	Landscape House, Premier Way, Lowfields Business Park, Elland, West Yorkshire, HX5 9HT	
Internet address / email	Roger.knight@marshalls.co.uk	
Additional information	Purchase order:	PQC011783
	Client Engineer:	Roger Knight

1.3 Test laboratory

Name	HORIBA MIRA Limited
Address	Watling Street, Nuneaton, Warwickshire, CV10 0TU. United Kingdom
Telephone number	+44 (0)24 7635 5000
Facsimile number	+44 (0)24 7635 8000
Internet address	http://www.horiba-mira.com
Test site location	At above address.
Accrediting body	United Kingdom Accreditation Service 21-47 High Street, Feltham, Middlesex. TW13 4UN
Accreditation details	HORIBA MIRA is designated as UKAS testing laboratory 1105, with approval dated 31 July 1992, subsequently renewed periodically, for details of the latest approval, and schedule of accreditation see: http://www.ukas.org/testing/lab_detail.asp?lab_id=826

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2 Test V0301

2.1 Pre-test

2.1.1 Test Procedure

Item	Requirement
Test Specification	PAS170-1: 2017
Target Speed (km/h)	16.0 +3.0 /-1.0
Target Impact Angle (°)	90.0 ±2.0
Target Impact Trolley mass (kg)	2500 ±75
Target Impact Energy (kJ)	98.8
Test Date	23/04/2018
Foundation Type	Rigid Foundation Socket

2.1.2 Test Item and Foundation Description

The tested item was mild steel bar, supplied by Marshalls Street Furniture, and cast into a rigid foundation with grade C40 concrete by Wilkinson Environmental.

The test item consisted of 75mm diameter mild steel bar with a height of 800mm above ground.

2.1.3 Concrete Crush Test Results

Item	Information / Measurement
Date Foundation Cast	21/03/2018
Concrete compressive crush test results for 150mm sample (MPa). Compressive testing carried out at CET at Wolvey UKAS Accredited Lab No. 0927 to EN12390-3: 2012 and EN12390-7: 2009.	
7 day	26.7
15 day	26.9
21 day	29.4
29 day	34.1

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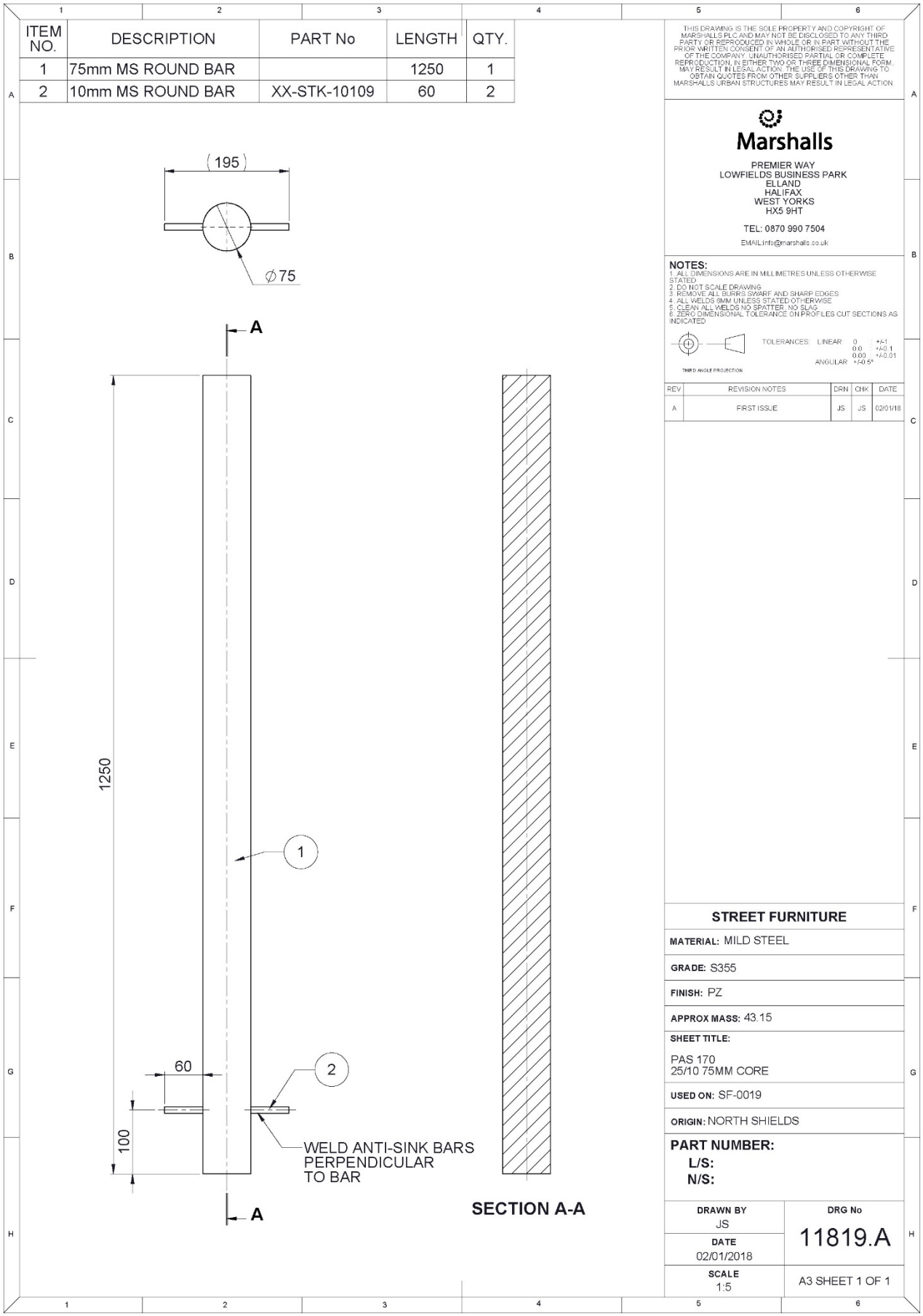
2.1.4 Test Item Drawing



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2.2 Test Results

2.2.1 General

Item	Information / Measurement
Impact Angle (°)	88.0
Impact alignment (mm)	53 Right
Impacted height (mm)	550
Impact velocity (km/h)	15.5
Impact energy (kJ)	23.2
Test Item Deflection from vertical, longitudinal (°)	23.0
Test Item Deflection from vertical, lateral (°)	-2.4
Foundation Deflection from vertical, longitudinal (°)	-0.5
Foundation Deflection from vertical, lateral (°)	0
Honey Comb Crush, Stage 1 (mm)	0
Honey Comb Crush, Stage 2 (mm)	0
Vehicle penetration - dynamic (m)	0.8
Vehicle penetration - static (m)	0.5

2.2.2 Test Description

On impact, the bollard deflected rearwards. As deflection reached 28.9° from vertical, the impact trolley began to ride up the test item. The impact trolley bumper then rode over the top of the test item sending the trolley into the air. On returning to ground the honeycomb was ejected from the impact trolley which came to a halt with the rear of the bumper against the rear face of the test item. The bollard then recovered to a static angle of 23.0°. The dynamic penetration was 0.8m, with a static penetration of 0.5m measured.

Peak force calculated from centre of gravity accelerometer was 40.1kN.

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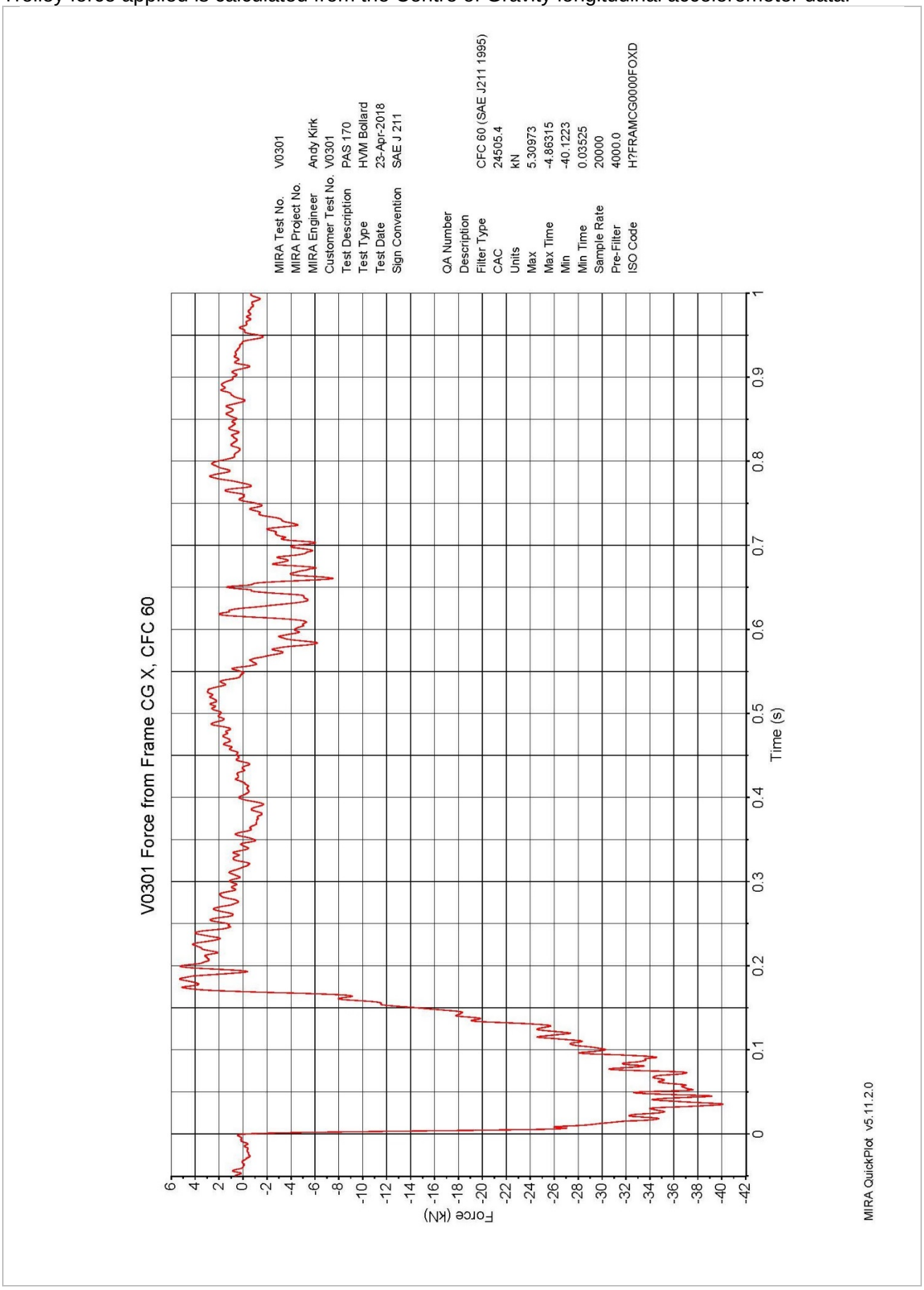
2.2.3 Trolley Force

Trolley force applied is calculated from the Centre of Gravity longitudinal accelerometer data.



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3 Test V0302

3.1 Pre-test

3.1.1 Test Procedure

Item	Requirement
Test Specification	PAS170-1: 2017
Target Speed (km/h)	16.0 +3.0 /-1.0
Target Impact Angle (°)	90.0 ±2.0
Target Impact Trolley mass (kg)	2500 ±75
Target Impact Energy (kJ)	24.7
Test Date	23/04/2018
Foundation Type	Rigid Foundation Socket

3.1.2 Test Item and Foundation Description

The tested item was fabricated steel bollard, supplied by Marshalls Street Furniture, and cast into a rigid foundation with grade C40 concrete by Wilkinson Environmental.

The test item consisted of an outer core of 101.6mm diameter CHS, 6.3mm wall, welded to an inner core made up four reducing diameter CHS (88.9, 76.1, 60.3 and 48.3), all with 5mm wall, with a height of 800mm above ground.

3.1.3 Concrete Crush Test Results

Item	Information / Measurement
Date Foundation Cast	21/03/2018
Concrete compressive crush test results for 150mm sample (MPa). Compressive testing carried out at CET at Wolvey UKAS Accredited Lab No. 0927 to EN12390-3: 2012 and EN12390-7: 2009.	
7 day	26.7
15 day	26.9
21 day	29.4
29 day	34.1

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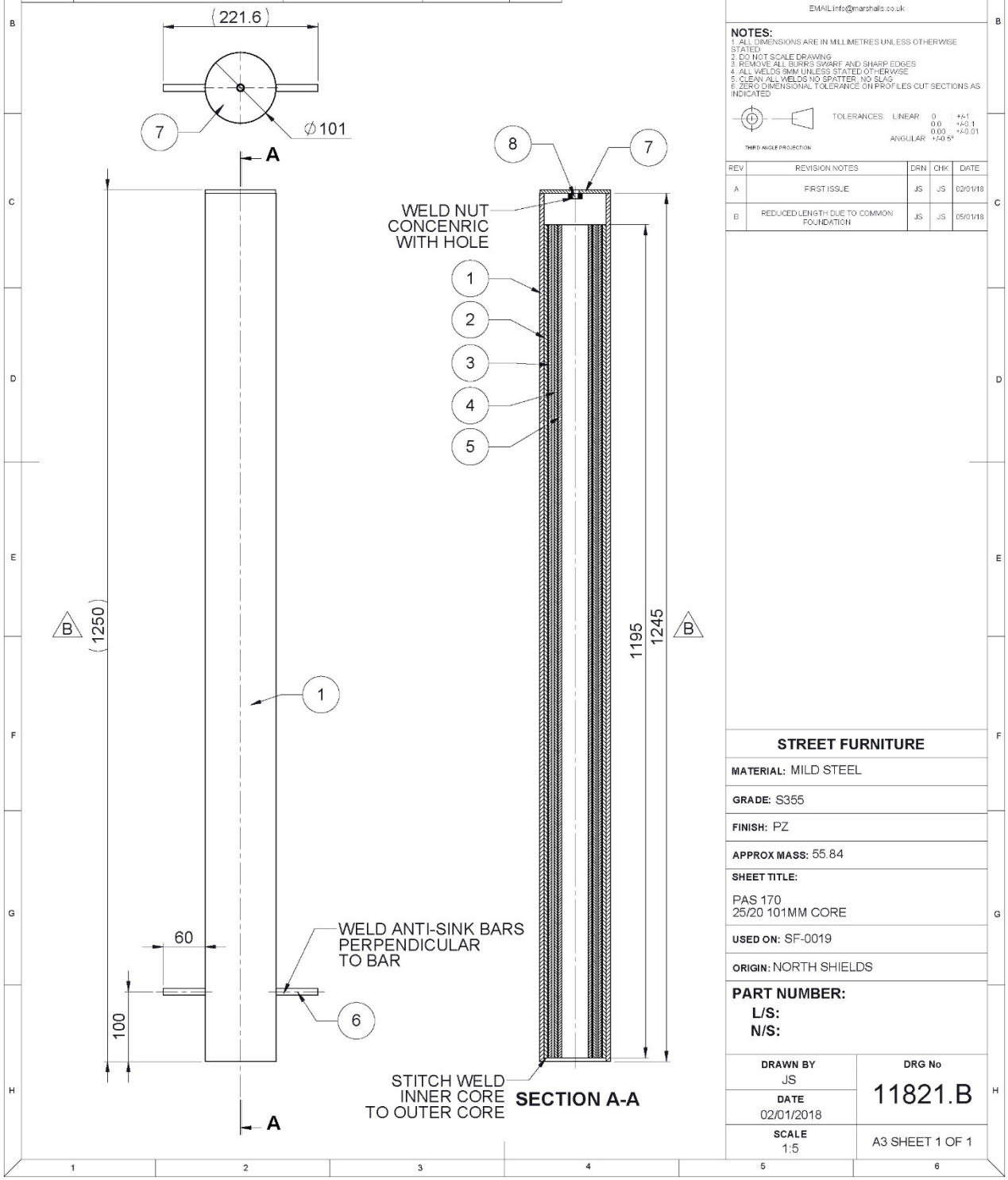
3.1.4 Test Item Drawing

ITEM NO.	DESCRIPTION	PartNo		QTY.
1	101.6 x 6.3 CHS		1245	1
2	88.9 x 5.0 CHS		1195	1
3	76.1 x 5.0 CHS		1195	1
4	60.3 x 5.0 CHS		1195	1
5	48.3 x 5.0 CHS		1195	1
6	10mm MS ROUND BAR	XX-STK-10209	60	2
7	TOP CAP			1
8	M10 FULL NUT			1



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Marshalls
PREMIER WAY
LOWFIELDS BUSINESS PARK
ELLAND
HALIFAX
WEST YORKS
HX5 9HT
TEL: 0870 990 7504
EMAIL:info@marshalls.co.uk

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4. ALL WELDS 6MM UNLESS STATED OTHERWISE.
5. CLEAN ALL WELDS NO SPATTER, NO SLAG.
6. ZERO DIMENSIONAL TOLERANCE ON PROFILES CUT SECTIONS AS INDICATED.

THIRD ANGLE PROJECTION

TOLERANCES: LINEAR 0 +/-1, 0.0 +/-0.1, 0.00 +/-0.01; ANGULAR +/-0.5°

REV	REVISION NOTES	DRN	CHK	DATE
A	FIRST ISSUE	JS	JS	02/01/18
B	REDUCED LENGTH DUE TO COMMON FOUNDATION	JS	JS	05/01/18

STREET FURNITURE

MATERIAL: MILD STEEL
GRADE: S355
FINISH: PZ
APPROX MASS: 55.84
SHEET TITLE: PAS 170 25/20 101MM CORE
USED ON: SF-0019
ORIGIN: NORTH SHIELDS
PART NUMBER:
L/S:
N/S:

DRAWN BY	DRG No
JS	11821.B
DATE 02/01/2018	
SCALE 1:5	A3 SHEET 1 OF 1

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3.2 Test Results

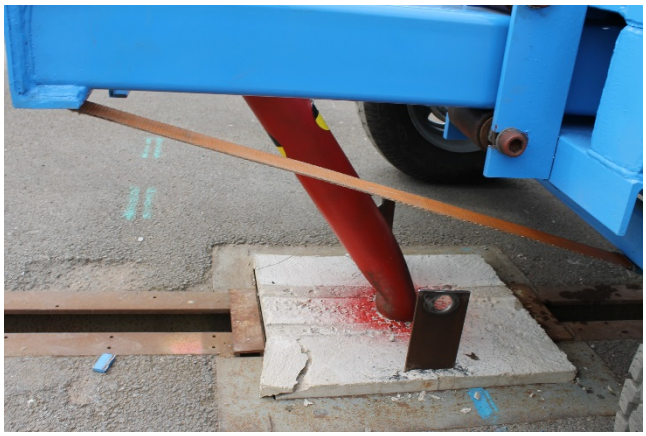
3.2.1 General

Item	Information / Measurement
Impact Angle (°)	88.1
Impact alignment (mm)	72 Right
Impacted height (mm)	550
Impact velocity (km/h)	15.9
Impact energy (kJ)	24.4
Test Item Deflection from vertical, longitudinal (°)	55.5
Test Item Deflection from vertical, lateral (°)	-25.0
Foundation Deflection from vertical, longitudinal (°)	0.9
Foundation Deflection from vertical, lateral (°)	-1.8
Honey Comb Crush, Stage 1 (mm)	0
Honey Comb Crush, Stage 2 (mm)	0
Vehicle penetration - dynamic (m)	1.1
Vehicle penetration - static (m)	1.0

3.2.2 System Damage Description

On impact, the bollard deflected rearwards. As deflection reached 56.5° from vertical, the impact trolley began to ride up the test item. The impact trolley bumper then rode over the top of the test item sending the trolley into the air. On returning to ground the honeycomb was ejected from the impact trolley which came to a halt with the rear of the bumper against the rear face of the test item. The bollard then recovered to a static angle of 55.5°. The dynamic penetration was 1.1m, with a static penetration of 1.0m measured.

Peak force calculated from centre of gravity accelerometer was 34.2kN.



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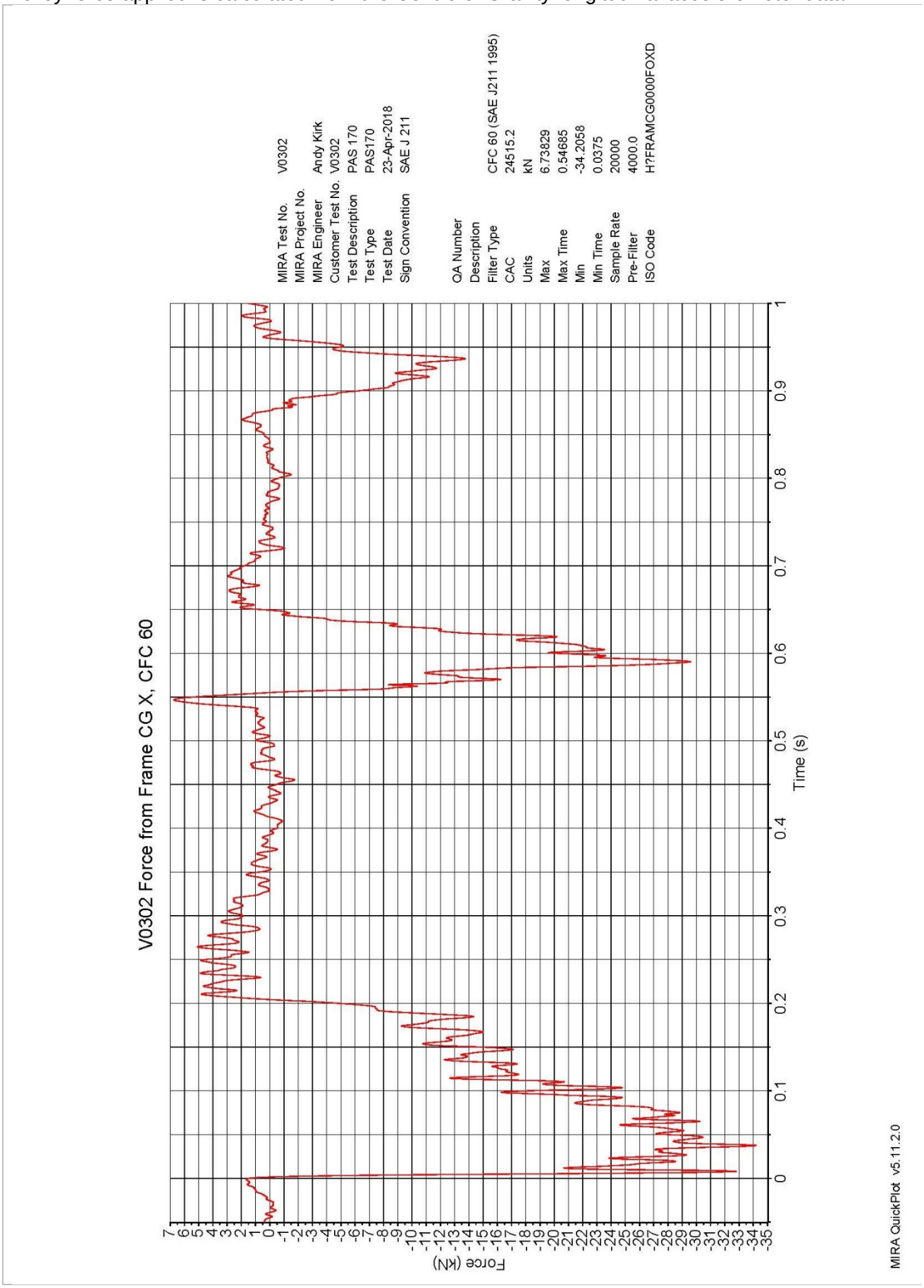
3.2.3 Trolley Force

Trolley force applied is calculated from the Centre of Gravity longitudinal accelerometer data.



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4 Test V0303

4.1 Pre-test

4.1.1 Test Procedure

Item	Requirement
Test Specification	PAS170-1: 2017
Target Speed (km/h)	16.0 +3.0 /-1.0
Target Impact Angle (°)	90.0 ±2.0
Target Impact Trolley mass (kg)	2500 ±75
Target Impact Energy (kJ)	24.7
Test Date	23/04/2018
Foundation Type	Rigid Foundation Socket

4.1.2 Test Item and Foundation Description

The tested item was fabricated steel bollard, supplied by Marshalls Street Furniture, and cast into a rigid foundation with grade C40 concrete by Wilkinson Environmental.

The test item consisted of an outer core of 139.7mm diameter CHS, 10mm wall, welded to an inner core of 114.3mm diameter CHS with 5mm wall, with a height of 800mm above ground.

4.1.3 Concrete Crush Test Results

Item	Information / Measurement
Date Foundation Cast	21/03/2018
Concrete compressive crush test results for 150mm sample (MPa). Compressive testing carried out at CET at Wolvey UKAS Accredited Lab No. 0927 to EN12390-3: 2012 and EN12390-7: 2009.	
7 day	26.7
15 day	26.9
21 day	29.4
29 day	34.1

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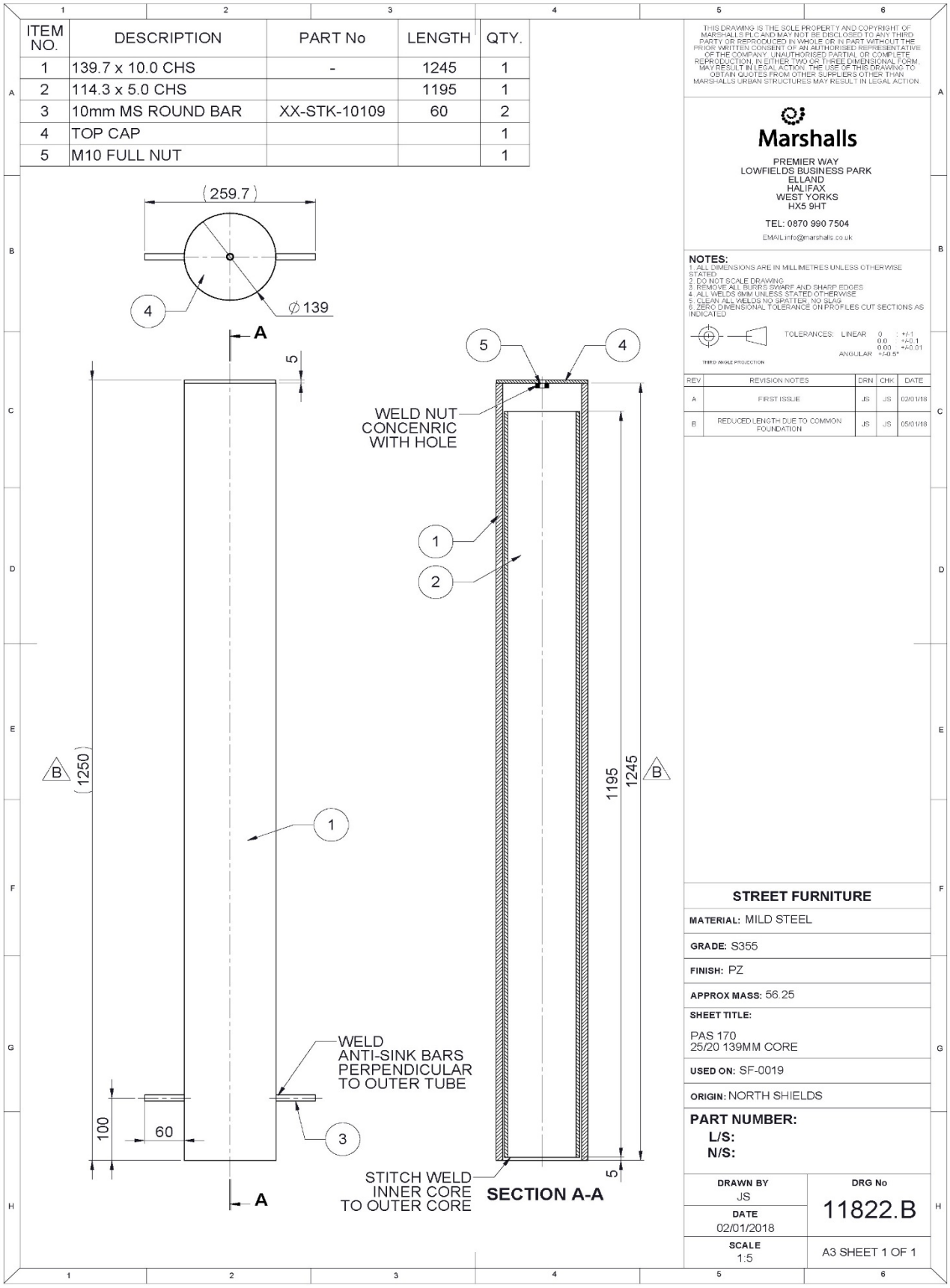
4.1.4 Test Item Drawing



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4.2 Test Results

4.2.1 General

Item	Information / Measurement
Impact Angle (°)	89.5
Impact alignment (mm)	62 Right
Impacted height (mm)	550
Impact velocity (km/h)	15.6
Impact energy (kJ)	23.5
Test Item Deflection from vertical, longitudinal (°)	23.6
Test Item Deflection from vertical, lateral (°)	-1.4
Foundation Deflection from vertical, longitudinal (°)	-1.3
Foundation Deflection from vertical, lateral (°)	-0.1
Honey Comb Crush, Stage 1 (mm)	0
Honey Comb Crush, Stage 2 (mm)	0
Vehicle penetration - dynamic (m)	0.2
Vehicle penetration - static (m)	0.0

4.2.2 System Damage Description

On impact, the tube deflected back to a maximum angle of 25.6° from vertical (longitudinal) then recovered to a static angle of 23.6°. The impact trolley was contained with 0.2m of dynamic penetration.

Peak force calculated from centre of gravity accelerometer was 54.5kN.

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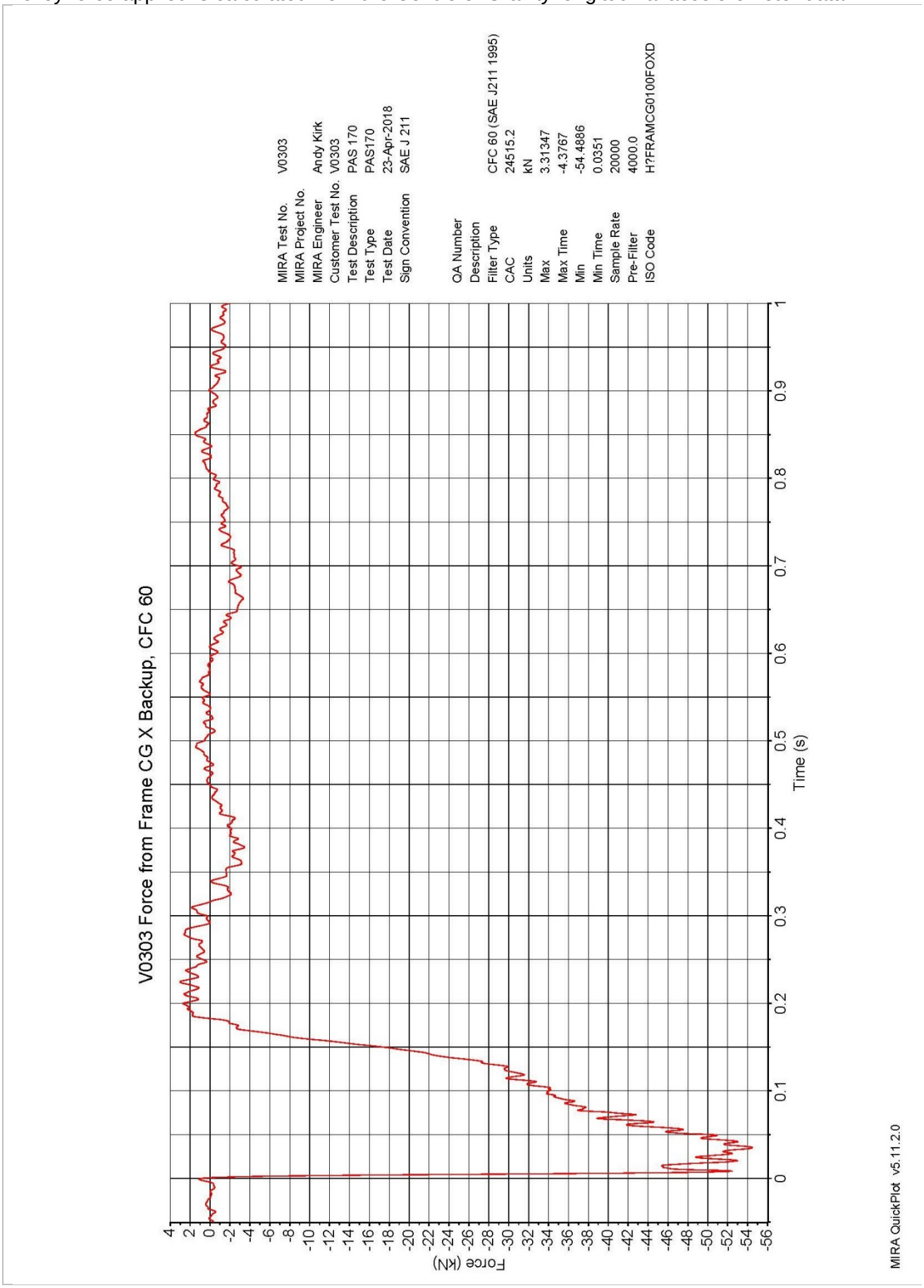
4.2.3 Trolley Force

Trolley force applied is calculated from the Centre of Gravity longitudinal accelerometer data.



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5 Test V0304

5.1 Pre-test

5.1.1 Test Procedure

Item	Requirement
Test Specification	PAS170-1: 2017
Target Speed (km/h)	32.0 +3.0 /-1.0
Target Impact Angle (°)	90.0 ±2.0
Target Impact Trolley mass (kg)	2500 ±75
Target Impact Energy (kJ)	98.8
Test Date	23/04/2018
Foundation Type	Rigid Foundation Socket

5.1.2 Test Item and Foundation Description

The tested item was fabricated steel bollard, supplied by Marshalls Street Furniture, and cast into a foundation with grade C40 concrete by Wilkinson Environmental.

The test item consisted of an outer core of 139.7mm diameter CHS, 10mm wall, welded to an inner core of 114.3mm diameter CHS with 5mm wall, with a height of 800mm above ground

5.1.3 Concrete Crush Test Results

Item	Information / Measurement
Date Foundation Cast	21/03/2018
Concrete compressive crush test results for 150mm sample (MPa). Compressive testing carried out at CET at Wolvey UKAS Accredited Lab No. 0927 to EN12390-3: 2012 and EN12390-7: 2009.	
7 day	26.7
15 day	26.9
21 day	29.4
29 day	34.1

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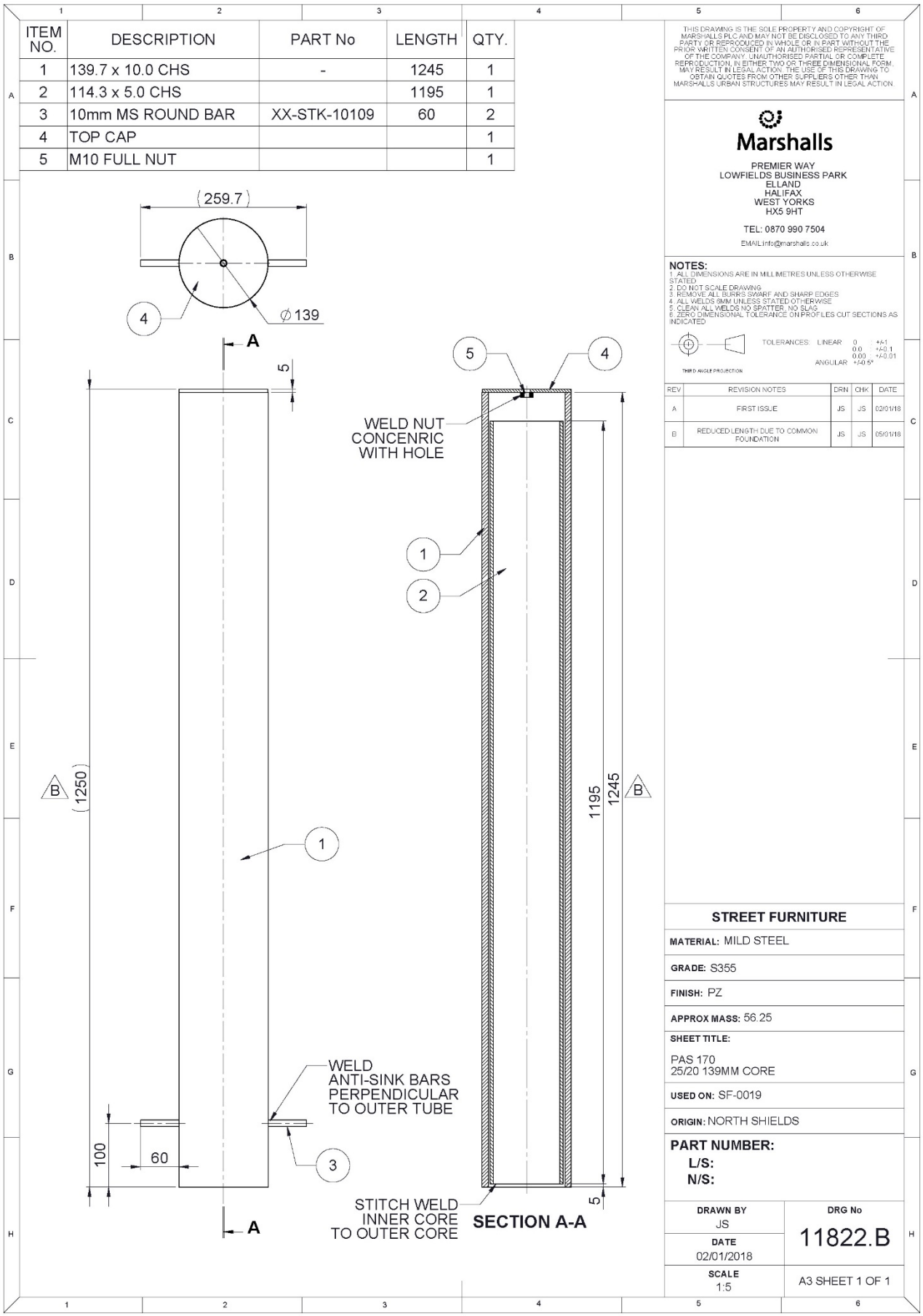
5.1.4 Test Item Drawing

ITEM NO.	DESCRIPTION	PART No	LENGTH	QTY.
1	139.7 x 10.0 CHS	-	1245	1
2	114.3 x 5.0 CHS		1195	1
3	10mm MS ROUND BAR	XX-STK-10109	60	2
4	TOP CAP			1
5	M10 FULL NUT			1



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Marshalls
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THIRD ANGLE PROJECTION

TOLERANCES: LINEAR 0 +/-1, 0.0 +/-0.1, 0.00 +/-0.01; ANGULAR +/-0.5°

REV	REVISION NOTES	DRN	CHK	DATE
A	FIRST ISSUE	JS	JS	02/01/18
B	REDUCED LENGTH DUE TO COMMON FOUNDATION	JS	JS	05/01/18

STREET FURNITURE

MATERIAL: MILD STEEL
GRADE: S355
FINISH: PZ
APPROX MASS: 56.25
SHEET TITLE: PAS 170 25/20 139MM CORE
USED ON: SF-0019
ORIGIN: NORTH SHIELDS
PART NUMBER:
L/S:
N/S:

DRAWN BY	DRG No
JS	11822.B
DATE 02/01/2018	
SCALE 1:5	A3 SHEET 1 OF 1

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5.2 Test Results

5.2.1 General

Item	Information / Measurement
Impact Angle (°)	89.5
Impact alignment (mm)	72 Right
Impacted height (mm)	552
Impact velocity (km/h)	32.8
Impact energy (kJ)	103.7
Test Item Deflection from vertical, longitudinal (°)	25.8
Test Item Deflection from vertical, lateral (°)	-2.6
Foundation Deflection from vertical, longitudinal (°)	0
Foundation Deflection from vertical, lateral (°)	-0.6
Honey Comb Crush, Stage 1 (mm)	147
Honey Comb Crush, Stage 2 (mm)	0
Vehicle penetration - dynamic (m)	2.0
Vehicle penetration - static (m)	1.8

5.2.2 System Damage Description

On impact, the test item deflected rearwards. As deflection reached 15.3° from vertical, the impact trolley bumper began to ride up the test item. The test item continued to deflect to 27.3°. The impact trolley bumper lost contact with the top of the test item and the test item rebounded to 24.6°. The impact trolley was deflected upwards before falling down with the trolley chassis contacting the top of the test item causing the test item to further deflect to 25.8° The impact trolley came to rest on top of the test item. Dynamic penetration was measured at 2.0m and static deflection was measured at 1.8m

Peak force calculated from centre of gravity accelerometer was 183kN.

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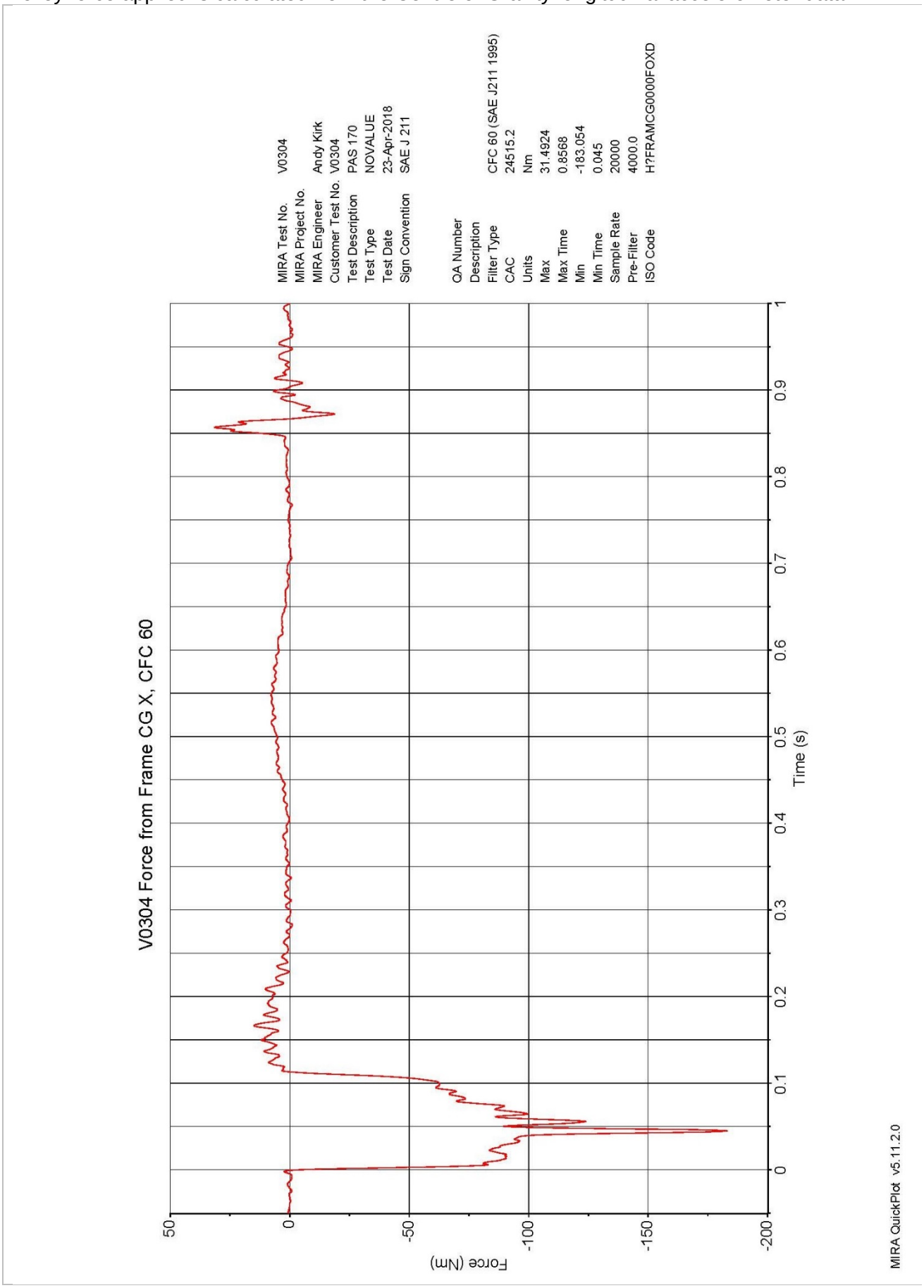
5.2.3 Trolley Force

Trolley force applied is calculated from the Centre of Gravity longitudinal accelerometer data.



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6 Test Results Summary

The test items were assessed according to PAS170-1: 2017 and achieved the following Classifications:-

Test No.	Test Item	Speed (km/h)	Performance Rating
V0301	Ø75mm steel bar	16	PAS170-1:2017 Bollard IT/2500/16/90:0.8
V0302	Ø101.6 fabricated steel bollard	16	PAS170-1:2017 Bollard IT/2500/16/90:1.1
V0303	Ø139.7 fabricated steel bollard	16	PAS170-1:2017 Bollard IT/2500/16/90:0.2
V0304	Ø139.7 fabricated steel bollard	32	PAS170-1:2017 Bollard IT/2500/32/90:2.0

7 General Comments and Disclaimers

The installation of the product was the responsibility of the product manufacturer or their representative.

The test results in this report relate only to the product tested.

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Opinions and interpretations included in this report are not part of the UKAS accreditation and are marked thus *.

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Appendix 1 Impact Trolley Details

Dimension	Specification	Measured
Trolley Manufacturer/supplier	Horiba MIRA designed and built	
A; Vehicle Length (mm)	5000±600	4455
B: Wheelbase (mm)	3000±300	3056
C: Centre of Gravity Horizontal (mm)[α]	1700±100	1747
D: Front Overhang (mm) [α]	1250±200	1056
E: Vertical thickness of impact bumper (mm)	150±25	150
F: Height from lower edge of impact bumper to ground (mm)	525±50	550
G: Tyre Radius (mm)	380±50	340
H: Centre of Gravity Vertical (mm) [α]	720±50	720
I: Chassis Width, outer edges (mm)	1300±50	1295
J: Wheel Track (mm)	1600±50	1600

[α] Measured with bumper beam in pre-test condition

Impact Trolley [IT2500] Test Mass Detail:-

	Specification	Left	Right	Total
Front	-	570.5	503.0	1073.5
Rear	-	679.5	752.5	1432.0
Total	2500±50	1250.0	1255.5	2505.5

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Appendix 2 Calibration Test Details

Calibration Test Date(s): 12th January 2018

Calibration Test Ref: V0300

Calibration Test Item Detail:-

Item	Specification	Measured
Diameter (mm)	219 ± 2	218
Wall thickness (mm)	19 ± 1	20
Height Above ground (mm)	1000 ± 50	1030
Depth into foundation (mm)	600 ± 50	570
Material	S355J2H	S355J2H

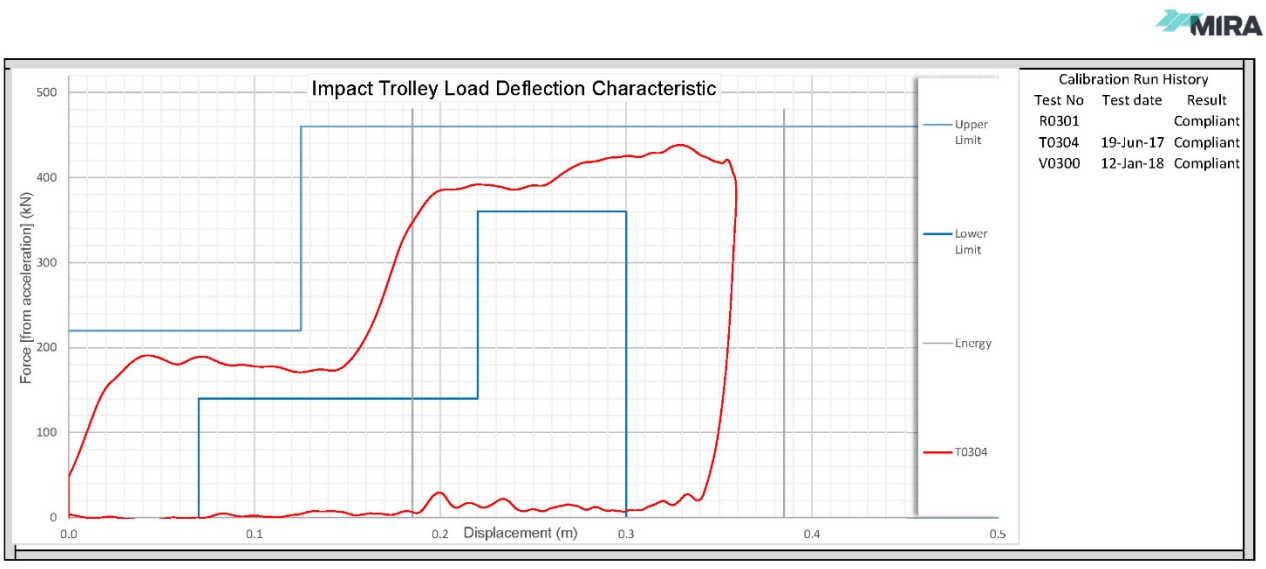
Impact Energy Absorber Detail:-

	X (mm)	Y (mm)	Z (mm)	Spec
Rubber collision attenuator	18	350	160	-
Aluminium Honeycomb Stage 1	170	330	200	5MPa
Aluminium Honeycomb Stage 2	300	330	200	2.2MPa

Calibration Test Detail:-

Item	Information / Measurement
Honeycomb Ref:	56MIR13-131355
Calibration Test Impact Speed (km/h):	33.0
Calibration Test Impact Angle (deg):	88.4
Calibration Test Impact Alignment (mm):	54 Right
Calibration Test Impact Height (mm):	565
Test Item Deflection from vertical, longitudinal (°)	2.8 dynamic, 1.2 static
Test Item Deflection from vertical, lateral (°)	0.0
Foundation Deflection from vertical, longitudinal (°)	0..39 dynamic, 0.89 static
Foundation Deflection from vertical, lateral (°)	0.0

Force Deflection Profile:-



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Appendix 3 Test Sign Off Sheet

Test No:	V0301-304

Product Information & Documentation

In line with legislative requirements please ensure the following information is provided by completing and returning this form and supplying the requested accompanying documentation.

Client Details	
Company name:	Marshalls Street Furniture
Company address:	Landscape House, Premier Way, Lowfields Business Park, Elland, West Yorkshire, Hx5 9Ht
Contact name:	Roger Knight
Contact tel:	0
Contact email:	roger.knight@marshalls.co.uk
Product Details	
Manufacturer:	Marshalls Street Furniture
Unique Product Name/Designation:-	N/A
Prototype or Production sample:	
What orientation is required:	
Test Vehicle Details	
Required Test Vehicle:	PAS 170 Trolley @ 2500 kg

Test Details

Test Number	Test Date	Speed km/h	Obstacle	Customer Sig	Horiba MIRA Sig
Test 1	23/04/2018	16	Ø75 x 800m core cast into foundation block		
Test 2	23/04/2018	16	Ø101.6 x 800m core cast into foundation block		
Test 3	23/04/2018	16	Ø139.7 x 800m core cast into foundation block		
Test 4	23/04/2018	32	Ø139.7 x 800m core cast into foundation block		

Test Sign-Off Above

Please sign below Confirm that:-

- The product and installation are to design intent and correct for test.
- The target test parameters are correct.

Comments/Agreed Deviations

Product Documentation Supplied	
General Arrangement drawings (including tolerences and installation instructions):	X
Component drawings (including dimensions, tolerences and material specifications):	N/A
Factory Sub-assembly drawings:	N/A
Parts List:	N/A
Material specification certificates:	N/A
Operating Manual	N/A
Other relevant information (disposal/recycling, safety instructions)	N/A

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Appendix 4 Calibration Information

Instrumentation

Location	QA No	CAC	Cal Due Date
Frame CG Pitch	045066	600deg/sec	07/12/2018
Frame CG Roll	045068	600deg/sec	07/12/2018
Frame CG X	041739	2000g	09/09/2018
Frame CG X Backup	041644	2000g	12/06/2018
Frame CG Y	041785	2000g	04/12/2018
Frame CG Y Backup	040404	2000g	12/06/2018
Frame CG Yaw	045069	600deg/sec	07/12/2018
Frame CG Z	041004	2000g	12/10/2018
Frame CG Z Backup	041639	2000g	14/06/2018

High Speed Cameras

Position	Camera QA No	Cal Due Date	Lens Type	Image Rate (pps)	X (m) to impact	Y (m) to impact	Z (m) to impact
Overhead	41527	23/03/2019	12mm	500	0.0	0.0	-12.4
Side	41528	23/03/2019	25mm	500	0.0	8.3	-1.2
Head-on	41525	23/03/2019	50mm	500	19.2	0.0	-1.5

Other Equipment

Item	QA No	Used For	Cal Due Date
VBox3i	36509	Speed and angle measure	08/09/2018
DTS Slice-pro SPS00316	40398	Data Acquisition	06/08/2018
Tape Measure	39698	Verify Post/Trolley dimensions	20/03/2021
Inclinometer	39700	Post/foundation angles	15/01/2019

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Appendix 5 Revision History

Report Number	Date	Comments	Sections Affected
1215709-002-01	15/06/2018	First Issue	n/a
1215709-002-02	20/06/2018	Updated incorrect trolley dimensions	Appendix 1 & 2

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