

Institute Of Rail Welding

10th Technical Seminar

16th November 2006

Rail Welding for Metro de Santiago
Lines 4 and 4A

Contents of Presentation

- ▶ Introductions
- ▶ Metro de Santiago
- ▶ Welding Scope
- ▶ Welding Methods
- ▶ Weld Quality
- ▶ Maintenance of Rail and Welds

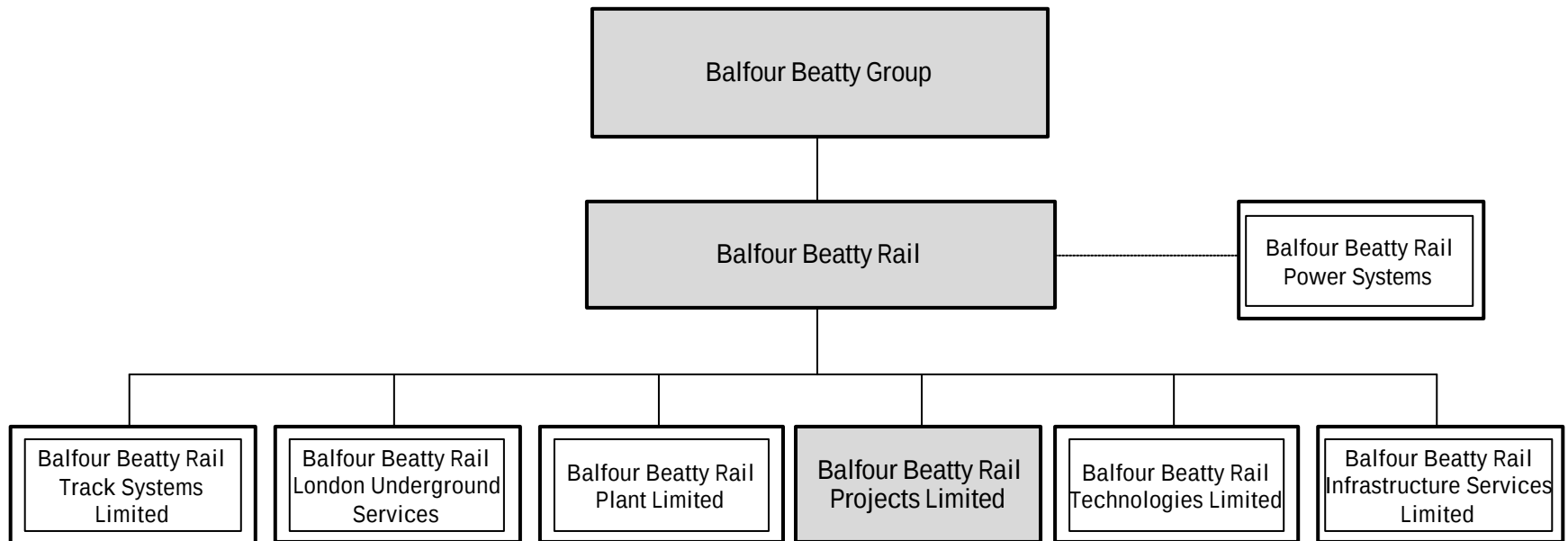


Introduction (1) – Derek Emmett

- ▶ Civil and Structural Engineer
- ▶ Highways and Railways
- ▶ Design and Construction
- ▶ Balfour Beatty Rail Projects 20 years
- ▶ Overseas Projects in
 - ▶ Saudi Arabia
 - ▶ Hong Kong
 - ▶ Singapore
 - ▶ Turkey
 - ▶ Switzerland
 - ▶ Chile



Introduction (2) – Balfour Beatty Rail Projects Limited



Introduction (3) – BBRPL Completed Projects Overseas

- ▶ Hong Kong
- ▶ Singapore
- ▶ Malaysia
- ▶ Turkey
- ▶ USA



Hong Kong

Singapore



Introduction (3) – BBRPL Current Projects Overseas

- ▶ Sweden
- ▶ Australia
- ▶ Singapore
- ▶ Chile



Santiago de Chile

Metro de Santiago (1) – Location

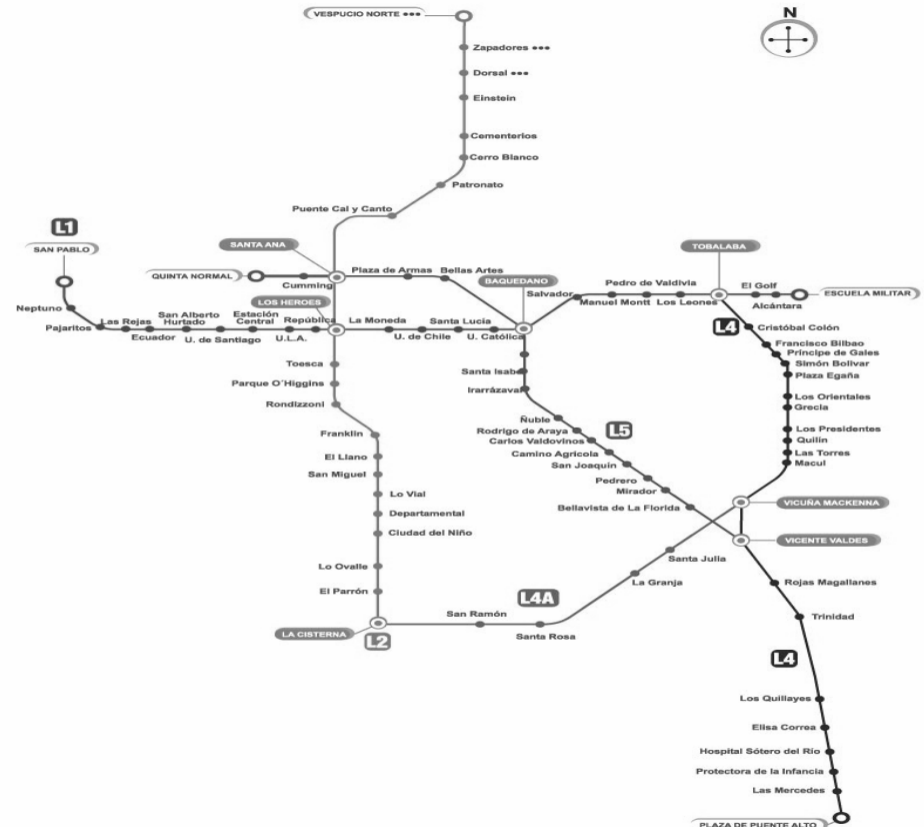
- ▶ Santiago de Chile
 - ▶ capital city of Chile
 - ▶ Population 5.5m of 16.4m in Chile
 - ▶ Financial centre, industry, agriculture



Metro de Santiago (2) – Extent of System

► Metro System

- ▶ 4 Lines operational
- ▶ 73 route kilometres
- ▶ 78 stations
- ▶ 1m passengers / day
- ▶ Lines 1, 2 and 5
 - rubber-tyred system
- ▶ Lines 4 and 4A – conventional steel rail/steel wheel system



Metro de Santiago (3) – Scope of Welding, Lines 4 and 4A

▶ Running Rail UIC60

- ▶ Flash Butt welding
- ▶ Aluminothermic welding

▶ Conductor Rail T52

- ▶ Aluminothermic welding

▶ Cast Crossings in Turnouts

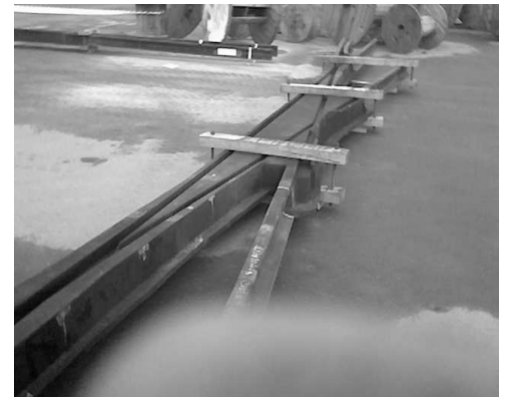
- ▶ Manual Metal Arc welding

▶ Conductor Rail Brackets

- ▶ Manual Metal Arc welding

▶ Column Tracks in Workshops

- ▶ Manual Metal Arc welding



Welding Methods – Aluminothermic (1)

- ▶ Rails – UIC60 Running Rail and T52 Conductor Rail
- ▶ Rail Grades
 - ▶ UIC60
 - ▶ Standard grade 900A
 - ▶ Heat treated HT
 - ▶ T52
 - ▶ Conductor rail steel
- ▶ Equipment
- ▶ Quantity
 - ▶ UIC60 approx 1100 no.
 - ▶ T52 approx 4100 no.



Welding Methods – Aluminothermic (2)

- ▶ **Set up rails**
- ▶ **Equipment**
- ▶ Pre-heating
- ▶ Reaction
- ▶ Pouring
- ▶ Remove moulds
- ▶ Shearing
- ▶ Grinding



Welding Methods – Aluminothermic (3)

- ▶ Set up rails
- ▶ Equipment
- ▶ **Pre-heating**
- ▶ **Reaction**
- ▶ **Pouring**
- ▶ Remove moulds
- ▶ Shearing
- ▶ Grinding



Welding Methods – Aluminothermic (4)

- ▶ Set up rails
- ▶ Equipment
- ▶ Pre-heating
- ▶ Reaction
- ▶ Pouring
- ▶ **Remove moulds**
- ▶ **Shearing**
- ▶ **Grinding**

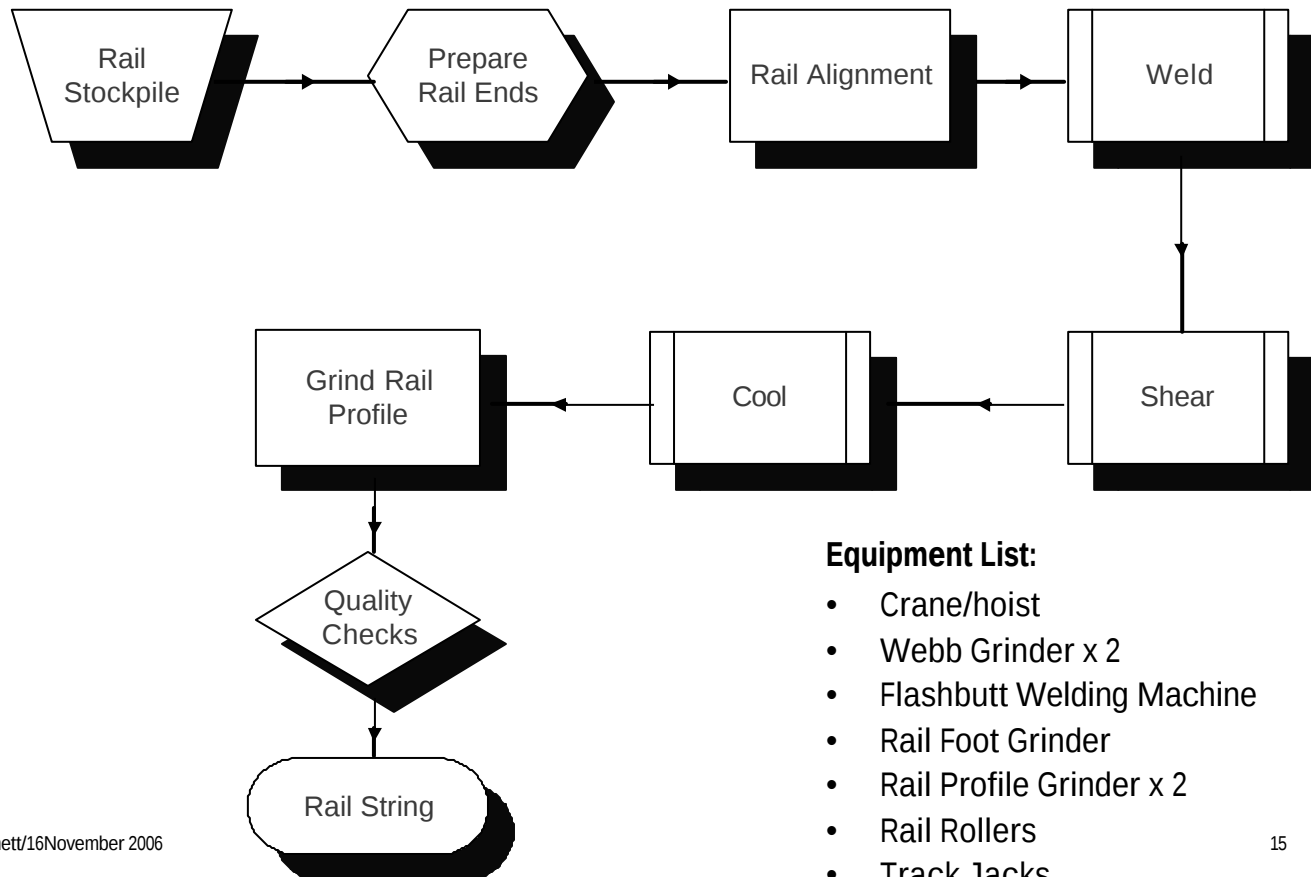


Welding Methods – Flash Butt (1)

- ▶ Machine
- ▶ Semi-permanent set up
- ▶ Rail grades UIC60
 - ▶ Standard grade 900A
 - ▶ Heat treated HT
- ▶ Quantity 7400 no. approx
- ▶ Rail string length 800m



Welding Methods – Flash Butt (2)



Equipment List:

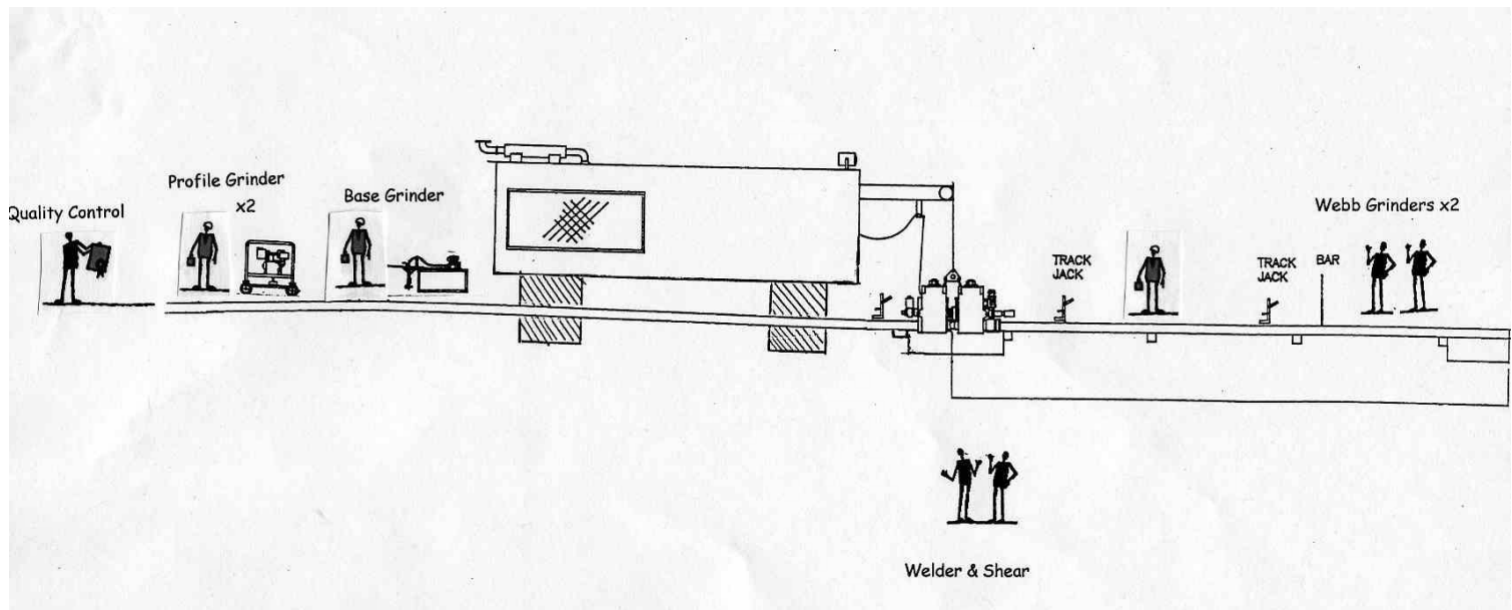
- Crane/hoist
- Webb Grinder x 2
- Flashbutt Welding Machine
- Rail Foot Grinder
- Rail Profile Grinder x 2
- Rail Rollers
- Track Jacks

Welding Methods – Flash Butt (3)

► Process Diagram

Equipment List:

- Mobile Containerised Flash Butt Welder
- Webb Grinder x 2
- Track Jacks
- Rollers
- Base Grinder
- Profile Grinder x 2



Welding Methods – Flash Butt (4)

- ▶ Rail stack
- ▶ Prepare rail ends
- ▶ Rail alignment
- ▶ Clamp
- ▶ Weld
- ▶ Shear
- ▶ Grind



Welding Methods – Flash Butt (5)

- ▶ Rail stack
- ▶ Prepare rail ends
- ▶ Rail alignment
- ▶ **Clamp**
- ▶ **Weld**
- ▶ **Shear**
- ▶ Grind



Technical Problems Encountered (1) – UIC60

- ▶ **Aluminothermic**
 - ▶ Weld defects
 - ▶ Ambient conditions
 - ▶ Daily output

- ▶ **Flash Butt Welding**
 - ▶ Semi-permanent set up
 - ▶ Length of rail strings
 - ▶ Alignment
 - ▶ Daily output



Technical Problems Encountered (2) – T52

- ▶ Rail section
- ▶ Rail position
- ▶ Sequence in construction
- ▶ Daily output



Welding Methods – MMA

- ▶ Cast Crossings in Turnouts
- ▶ Column Tracks
- ▶ Conductor Rail Brackets
- ▶ Steel Grades
- ▶ Welding Procedures
- ▶ Quantities



Welding Methods – Cast Crossings

- ▶ Repair
- ▶ Build-up



Welding Methods – Column Tracks (1)

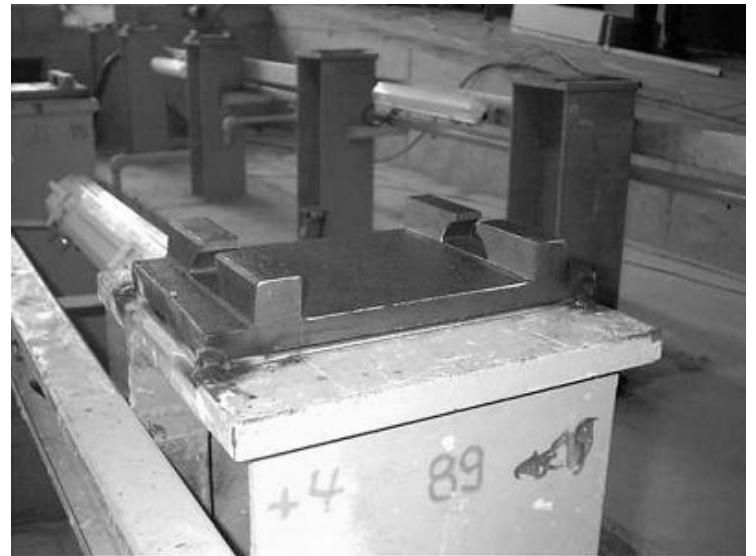
- ▶ In-situ welding
- ▶ Steel grades
- ▶ Quantity approx 1000 no.
- ▶ Welding procedure



Welding Methods – Column Tracks (2)



Set up



Check alignment

Welding Methods – Column Tracks (3)



Completed welds

Welding Methods – Column Tracks (4)

► Procedure developed by Balfour Beatty Rail Track Technologies

Balfour Beatty Rail

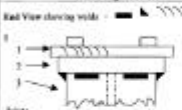
Welding Procedure Specification (WPS)

Location: Santiago Express Chile
Manufacturer's Welding Procedure:
Reference No: B20 - 0914
gms/cv
Welder Qualification: BS EN 287 or equivalent
Welder's Name:
Welding Process: Manual Metal Arc (MMA)
Joint Type: (Fillet) Fillet
Weld Preparation Details: (Sketch)

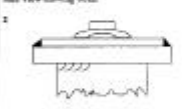
Examination or test body: Metal's Santiago de Chile
Method of Preparation and Cleaning: Wire brush & Acetone
Material Specifications: S275JR D6106 18025, A 37 3425
Material Thicknesses: 20mm approx
Outside Diameter (approx): N/A
Welding Position: In - Side Girth/Down head (Flat)

Joint Design Sketches

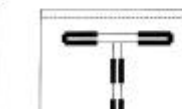
End View showing weld:



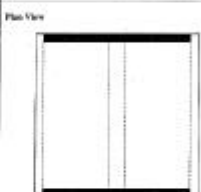
Side View showing weld:



View From Underneath showing weld:



Plan View



Welding Conditions

Joint 1 or 2 shall be made in the flat position.
And shall comprise 2 x runs x 240mm fillet HV welds (see sketch 2).

Joint 2 to 3 shall be made in the overhead position.
And shall comprise 2 x runs x 240mm fillet HV welds (see sketch 2).

Welded plate to be aligned (as required) with end correctly chamfered to the baseplate. Suitable marks to be placed. The weld to be made in one pass to a 3mm HV fillet across the width of the baseplate.

The baseplate to be clamped or supported continuously on the steel columns. Suitable tack welds shall be made in the above welding positions. The welds shall be made in the flat position as shown in the sketches.

In the interests of full alignment it may be beneficial to weld the baseplate to the columns in the first operation. This shall be decided by the site management.

Welding Details

Run	Process	Size of Electrode	Current A	Are Voltage	Type of Current / Polarity	Wire Speed Feed	Travel Speed mm/min	Heat Input
1 HV	MMA	4.00mm	165-185	24-25	DC + VE	N.A.	150 mm/min (approx)	1.7kJ/mm (approx)
2 OH	MMA	4.00mm	115-135	24-25	DC + VE	N.A.	100 mm/min	1.6kJ/mm (approx)

Filler Metal Classification: AWS A5.1 E7018

Electrode Type / Size: Low Hydrogen Basic, 4.00mm dia.

Any Special Baking or Drying: Use VacPac follow manufacturer's instructions after opening, or dry according to manufacturers instructions

Details of Back Gouging: N.A.

Preheat Temperature: 50 °C to be maintained 75mm beyond extremities of the weld area.

Interpass Temperature: Unspecified

Deposition Technique: Use a short arc, run over arc initiation site to prevent start porosity, prevent occurrence of end craters. All tack welds to be blended in.

Post - Weld Heat Treatment and / or Ageing: N.A.

Time, Temperature, Method: NA

Heating and Cooling Rates: N.A.

Prepared by: Bob Sawdon

Date: 14/09/04

Signature: *Bob Sawdon*

Additional Information:

Post Weld Treatment:
Cleaning: the completed deposit shall be thoroughly de-slugged.

Non - Destructive - Examination: Visual inspection, any craters, valleys or hollows to be re-welded. M.P.L/DPI to be employed as required.

Other Information:

Manufacturer: Balfour Beatty Rail Projects Limited

Issued by:

Date:

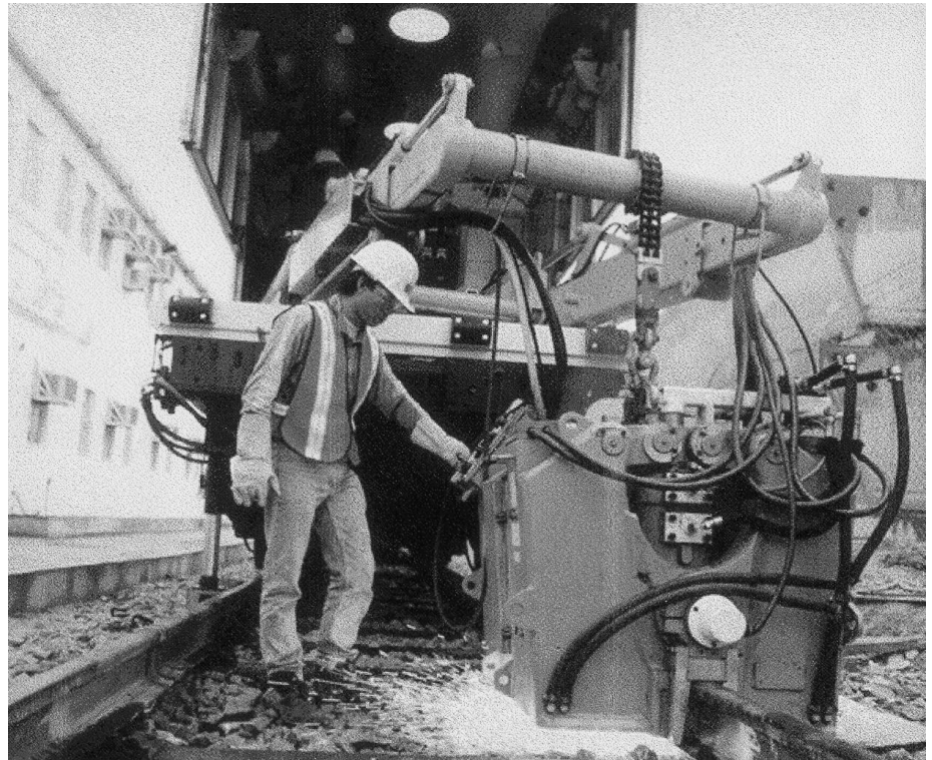
Signature:

A black and white photograph showing a person from the waist down, wearing a dark jacket and light-colored trousers, standing on a dark, textured floor. To the right of the person is a metal structure, possibly a door or gate, with a small, dark, rectangular object on the floor. The object has some faint markings on it, including the number '1' and the word 'SPE'. The background is a plain, light-colored wall.

-
- Technical drawing of a mechanical assembly, likely a pump or motor component. The drawing includes a top view and a side view. The top view shows a rectangular base with a central circular feature and a smaller circular feature on the right. The side view shows a cross-section of the assembly, including a pump head and a motor. The drawing includes dimensions, a title block, and a list of parts.
- Technical Drawing Details:**
- Top View:** Shows a rectangular base with a central circular feature and a smaller circular feature on the right. Dimensions include 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000.
 - Side View:** Shows a cross-section of the assembly, including a pump head and a motor. Dimensions include 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000.
 - Title Block:** Located in the bottom right corner, containing the following information:
 - Project Name: [Blank]
 - Project Number: [Blank]
 - Project Date: [Blank]
 - Project Location: [Blank]
 - Project Description: [Blank]
 - Project Status: [Blank]
 - Project Manager: [Blank]
 - Project Engineer: [Blank]
 - Project Designer: [Blank]
 - Project Checker: [Blank]
 - Project Approver: [Blank]
 - Part List:** Located in the bottom left corner, containing the following information:
 - Part Name: [Blank]
 - Part Number: [Blank]
 - Part Description: [Blank]
 - Part Status: [Blank]
 - Part Manager: [Blank]
 - Part Engineer: [Blank]
 - Part Designer: [Blank]
 - Part Checker: [Blank]
 - Part Approver: [Blank]

Welding Methods – General

- ▶ Welder training and certification
 - ▶ 12 welding teams
- ▶ Welding process approval
 - ▶ Aluminothermic
 - ▶ Flash Butt
 - ▶ MMA



Weld Quality – Aluminothermic (1)

- ▶ **Procedural checks**
- ▶ Geometry checks
- ▶ Ultrasonic checks

- ▶ Consolidated Weld Report

Balfour Beatty		Contrato N° VPA-1001-01-03 Sistema de Vías LINEA 4 Y 4A - METRO DE SANTIAGO
Informe Consolidado de Soldadura		
Número de Documento: BB-CC-013	Revisión: 1	Fecha Efectiva:
SOLDADURA ALUMINOTERMICA		
		Informe N°:
Tiempo: Húmedo / Seco - Cálido / Frío	Hora de Soldadura:	Fecha de Soldadura:
Ubicación :		
Sector :		
Vía :		
PK :		
Geometría de vía : Recta / Curva / Transición	Marca y Tipo de Riel :	
Riel a Riel : SIS SIP PIP	Soldadura N° :	
S: Standard; P: Premium (trabajo térmico).		
Datos de Soldadura (Se debe hacer el registro al mismo tiempo que se suelda)		
Proceso : KLK	Distancia libre (mm) :	24 mm ± 2 mm
Molde usado : 3 piezas	Precalentamiento crisol :	
Gas usado : Oxy-Acetileno	Precalentamiento soldadura :	
Presión Oxígeno : 2,6 bar	Estado del Crisol :	
Presión Acetileno : 1 bar	Numero carga crisol :	
Tiempo de desmolde :	Tiempo de Corte de Mazorota :	
Alineación carril : Interna / Externa	Tiempo de reacción [s] :	
Alineación patín : Interna / Externa	Tiempo de duración de la soldadura :	
Alineación carril : Horizontal / Vertical	Estado punta de carriles	
Alineación patín : Horizontal / Vertical	Espera ☐ Rebarba ☐ Resos sold ☐ Grasa ☐ Chispas ☐	
Observaciones:		
Estos trabajos se deben llevar a cabo bajo la aprobación del supervisor y soldador		
Soldador:	Control de Calidad BB:	
Firma:	Firma:	
Supervisor:	ITO:	
Firma:	Firma:	

Weld Quality – Aluminothermic (2)

- ▶ Procedural checks
- ▶ **Geometry checks**
- ▶ Ultrasonic checks

- ▶ Consolidated Weld Report

Balfour Beatty										
Contrato N° VPA-1001-01-03										
Sistema de Vías LINEA 4 Y 4A - METRO DE SANTIAGO										
Control de Esmerilado Final de Rieles										
Número de documento: BB-CC-056 Rev:0 Fecha de Emisión: 15/6/2005										
Via:		Fecha:		Control de Alineación Vertical		Control de Alineación Horizontal				
Tolerancias:				Vertical		Horizontal				
N°	PK	N° de Rielada	N° de Soldadura	DI	OK/NO	OK/NO	OK/NO	OK/NO	OK/NO	Area de Esmerilado
1										
2										
3										
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30										
31										
32										
33										
Comprobado por: Departamento de Calidad BB					Revisado por Supervisor			Revisado por ITO		
Nombre:					Nombre:			Nombre:		
Firma Fecha:					Firma Fecha:			Firma Fecha:		

Weld Quality – Aluminothermic (3)

- ▶ Procedural checks
- ▶ Geometry checks
- ▶ **Ultrasonic checks**
- ▶ Consolidated Weld Report

Balfour Beatty

Contrato N° VPA-1001-01-03
 Sistema de Vías LINEA 4 Y 4A DEL METRO DE SANTIAGO

Registro - Soldadura Aluminotérmica

Número de Documento: BB-CC-011

Revisión: 1

Fecha emisión: 20/10/2004

Talleres Tocornal: (0000-1000)
 Cocheras Quilín:

No.	Sector	PK	Vía	N° Soldadura	Tipo de Unión* S/S, S/P, P/P	Rango de Esmerilado	Resultado Ensayo Ultrasonido ENOC	Alineación vertical	Alineación Horizontal
1									
2									
3									
4									
5									
6									
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25									
26									
27									
28									
29									

S/S: Unión rieles Standard. S/P: Unión riel standard/premium (tratado). P/P: Unión rieles Premium (tratados)

VISTA EN ELEVACION, TOLERANCIAS DEL CONTROL VERTICAL

VISTA EN PLANTA, TOLERANCIAS DEL CONTROL HORIZONTAL

Soldador:

Inspeccionado por: Departamento Control de Calidad

Nombre:

Firma/Fecha:

Comprobado por: ITO

Nombre:

Firma/Fecha:

Weld Quality – Aluminothermic (4)

- ▶ Procedural checks
- ▶ Geometry checks
- ▶ Ultrasonic checks

- ▶ **Consolidated Weld Report**

Balfour Beatty

Contrato N° YPA-1001-01-03
 Sistema de Vías LINEA 4 Y 4A DEL METRO DE SANTIAGO

Registro - Soldadura Aluminotérmica

Número de Documento: BB-CC-011

Revisión: 1

Fecha emisión: 20/10/2004

Talleres Tocornal: (0000-1000)
 Cocheras Quilín:

No.	Sector	PK	Vía	N° Soldadura	Tipo de Unión* S/S, S/P, P/P	Rango de Esmerilado	Resultado Ensayo Ultrasonido ENOC	Alineación vertical	Alineación Horizontal
1									
2									
3									
4									
5									
6									
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27									

S/S: Unión rieles Standard, S/P: Unión riel standard/premium (tratado), P/P: Unión rieles Premium (tratados)

VISTA EN ELEVACION, TOLERANCIAS DEL CONTROL VERTICAL

VISTA EN PLANTA, TOLERANCIAS DEL CONTROL HORIZONTAL

Soldador:

Inspeccionado por: Departamento Control de Calidad

Nombre:

Firma/Fecha:

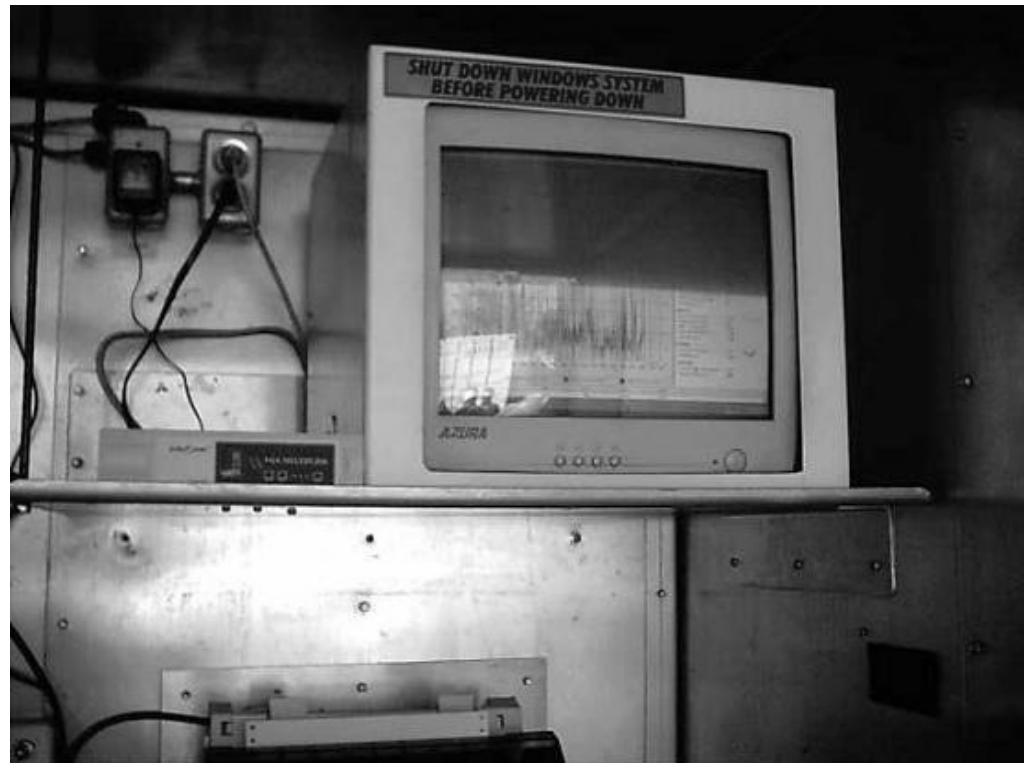
Comprobado por: ITO

Nombre:

Firma/Fecha:

Weld Quality – Flash Butt

- ▶ **Chart output**
- ▶ Geometry checks



Maintenance of Welds

- ▶ Up to commissioning
- ▶ First two years
- ▶ Long term



Summary

- ▶ Metro de Santiago Lines 4 and 4A
- ▶ Welding Scope
- ▶ Welding Methods and Technical Problems
- ▶ Quality Control
- ▶ Maintenance

Questions and Answers

