

Network Rail

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**King's Cross Station  
Redevelopment  
Programme Package 6  
GRIP 5**

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Civil Specification Volume  
7: Structural Steelwork for  
Works Excluding the  
Western Concourse Roof

**Job Number 123345-00**

Document ref  
ENG-SPE-G5-OAP-006-  
CSTR-0151

Issue 2.0

**Issue for Construction**

CCMS Number: 6231936

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Civil Specification  
Volume 7: Structural  
Steelwork for Works  
Excluding the Western  
Concourse Roof

March 2008

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Job number 123345

Job title	King's Cross Station Redevelopment Programme Package 6 GRIP 5			Job number	123345
Document title	Civil Specification Volume 7: Structural Steelwork for works Excluding the Western Concourse Roof			File reference	
Document ref	ENG-SPE-G5-OAP-006-CSTR-0151				

  

Revision	Date	Filename	0001Rpt Nat Structural Steelwork Spec 30-04-07]#.doc		
Issue 1	07/12/07	Description	Issue for Tender		
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Issue 2	04/03/08	Filename	Civil Specification Volume 7 Structural Steelwork for Works Excl WCR.doc		
		Description	Network Rail comments incorporated. General review before Issue for Construction. Issued for GRIP5B Production Information		
			Prepared by	Checked by	Approved by
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			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

  

Issue Document Verification with Document ☒

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**DEFINITIONS**

The following definitions apply for the purposes of this Specification:

The Works	Structural Steelwork as shown on the Design Drawings for the Western Concourse Mezzanine and Link Bridge, the Suburban Train Shed south end, and the West Range Buildings and associated pub mezzanine between the Suburban Train Shed south end and the West Range Buildings.  The specification for the early package of steelwork (the Western Concourse Roof and cladding) see document ENG-SPE-G5-OAP-006-CSTR-0145.
Design drawings	Drawings produced by the ER's design team
Employer	Delete all references to "Employer" and replace with "Employer's Representative" (see below).
Employer's Representative (ER)	Such person(s) as may be nominated by the Employer to act as such for the purposes of the Contract. Refer to the Network Rail 12 Contract for the Works.
Engineer	Delete all references to "Engineer" and replace with "Employer's Representative" (see above).
Examiner/Examining Body	An independent person or organisation who has been accredited by UKAS (ISO 9001) as being competent to verify compliance of welder tests to BS EN 287 and welding tests to BS EN ISO 15614. Personnel who witness procedures shall be approved inspectors (PCN, EN 473) and approvals shall be by a qualified welding technologist (certified IWT or above).
FSBW	Full strength butt weld, a weld that is not full penetration but is designed to develop the full strength of the connection, it may have an un-fused land in the centre.
FPBW	Full penetration butt weld, a weld that is fully fused for the full thickness of the material
PPBW	Part penetration butt weld, similar to a FSBW but is not designed to develop the full strength of the connection and will have an un-fused land
FW	Fillet weld is normally between two plates at right angles. It can also apply to plates lapped (lap weld).
LPR	Link Plant Room
STS	Suburban Train Shed. For the purposes of this specification, this is taken to mean only the South End in the vicinity of Gridlines T1 - T3/TA-TB.

WCC	Western Concourse. Several elements make up the Western Concourse and these are referred to as the WCC Mezzanine (including the suspended floor at first level, and the canopy over this floor), the and WCC link bridge (between the WCC Mezzanine and the West Range Buildings). The WCC Roof (including the vertical glazed side walls) refers to the early steelwork package and is excluded from this specification.
Working drawings	Drawings produced by the contractor, or (if referenced "by others") produced by contractors with which the works covered by this specification interface. This would include "Fabrication Drawings", "Erection Drawings", "General Arrangement Drawings" produced by the contractor (as defined in the NSSS).
Works Package Plans	Network Rail requires works package details, method statements and construction sequences to be submitted as Works Package Plans
WRB	West Range Buildings. The Grade 1 listed buildings on the west side of the Main Train Shed of King's Cross Station

# 1 INFORMATION REQUIRED BY STEELWORK CONTRACTOR

## 1.1 Project Specification for Structural Steelwork

### 1.1.2 Reference to National Structural Steelwork Specification

The National Structural Steelwork Specification for Building Construction 5th Edition (NSSS) as modified by this project specification applies to the King's Cross Station Redevelopment Programme Package 6 GRIP 5. Read the specification in conjunction with all other contract documents and Civil and Structural Specifications. A separate specification is provided for the steelwork in the main roof to the WCC.

The clause numbering in this Project Specification matches the number of the NSSS.

- Clauses in this Project Specification replace the clauses in the NSSS.
- Clauses in this Project Specification numbered with an 'M' are modifications to the NSSS clauses.
- Clauses in this Project Specification numbered with an 'A' are additions to the NSSS clauses.

The steelwork contract is subordinate to the Network Rail 12 Contract between Network Rail Infrastructure Limited and the Main Contractor.

Table 1.1 Proposed Works

- i.) The structures to be erected include:
- A Mezzanine inside the WCC, with an independent roof canopy;
  - A link bridge between the Mezzanine and the West Range Buildings;
  - A remodelled south end to the STS, closely associated with a new mezzanine floor with glazed roof to a pub proposed in the West Range Buildings; and
  - Various elements forming interventions, modifications or strengthening to the existing Grade 1 listed WRB.
- ii.) The structures will accommodate:
- Retail facilities on and below the WCC Mezzanine;
  - A pedestrian link from the Mezzanine to the WRB via the bridge, leading passengers to a gate-line in the WRB and thence to an access to the Main Train Shed platforms from high level;
  - A link, with gateline, for passengers moving from the STS into the main Western Concourse; and
  - Offices for Network Rail and Train Operating Companies and retail, pub and other passenger facilities in the WRB.
- iii.) Details of the site are provided by the ER.
- iv.) The structures are Class 2A in accordance with the Building Regulations Approved Document A3, Section 5.

Table 1.2A Design

- i.) The design concept for the various elements of the works are described below.

The primary structure is designed for a 120 year life. Elements which require maintenance, such as the coating systems, are specified with a view to increasing the period to first maintenance as much as reasonably possible.

- WCC Mezzanine. The Mezzanine is a composite steel beam/concrete/profiled metal deck floor. The steel beams frame on steel circular hollow section columns that are founded either on the columns or roof slab of the London Underground Northern Ticket Hall below the WCC or onto the grillage of reinforced concrete ground beams constructed to support the WCC outside of the Northern Ticket Hall.

There is a local roof or "canopy" over the Mezzanine which is clad in ceramic tiles on a curved plywood base. A structural steel frame is required to support the plywood system. Steel posts springing off the Mezzanine floor support a series of primary members arranged radially around the centre point of the main WCC roof. These primary beams have a compound shape consisting of UB sections either straight or rolled to a defined radius about their major axis. Square hollow section secondary members connect between the primaries. These will turn support timber tertiary members via an adjustable fixing which can be used to accommodate fabrication and erection tolerances in the steel frame, as indicated on the design drawings.

The Mezzanine floor is stabilised by the three reinforced concrete lift shafts that connect the ground and Mezzanine levels. The Mezzanine roof is stabilised by steel bracing in the plane of the roof, and by detailing the connections between the roof support posts and the primary beams to have moment resisting capacity to act as portal frames.

- WCC Link Bridge. This is formed from a fabricated steel box girder spine with projecting steel ribs to support the bridge floor deck and the balustrades. The box girder is curved on plan. The girder is supported by concrete walls erected off ground level slab over the Northern Ticket Hall and one end and new concrete structure introduced into the WRB at the other. A single off-centre steel column on grid r14 divides the bridge into two spans. Lateral restraint and some torsional restraint is provided by the supports at each end.
- STS south end. Three new steel columns on piled foundations on the west side and two on the east side in line with the existing STS flank walls support a composite plate-girder/concrete/profiled metal deck floor. The north edge of this floor deck supports the ends of steel rafters for a new lightweight roof that fills the gap between the first retained truss of the historic STS roof and the edge of the new deck. The south edge of the deck cantilevers out beyond the column line to form a circular edge following the line of the Main WCC roof. This cantilevering deck is required to receive vertical loads from the main WCC roof via vertical steel posts. The posts have a pin joint at each end to prevent horizontal loads from being transmitted between the two structures.

Stability of the new STS south end in the north-south direction is provided by plane bracing between the columns on the east and walls. In the east-west direction stability is achieved by portalisation of the columns and plate girders using "wind moment frame" assumptions.

The new STS south end frame is required to give lateral support to the historic masonry flank walls of the STS, replacing a temporary bracing system introduced to restrain the walls while the south gable wall is demolished. This is achieved by connecting the new steel columns to the ends of the walls using connections that allow lateral but not vertical load transfer.



To the east of the STS the new steel structure effectively continues to the face of the WRB. Further steel columns at the WRB façade support an extension of the STS roof steel/concrete deck. This forms an access walkway between the WRB, the WCC main roof and the STS roof, where it is proposed to locate a standby generator. The steel/concrete deck also supports the ends of cranked steel rafters for a new glazed roof over the old "parcels courtyard" between the STS, the WRB and the "Parcels Office".

Below the parcels yard roof is new composite steel beam/concrete/profiled metal deck floor on steel columns forming the "pub mezzanine".

- WRB modifications. Structural steel is used in a number of elements of modifications to the existing Grade 1 listed WRB, including:
  - Steel lintels, goal-posts or complete "picture frames" to support and stiffen the existing masonry walls where new openings are required
  - Framing to new stairs
  - Strengthening of existing timber joist floors
  - Framing around new openings through existing floors
  - Supporting new floor elements, including steel beam/concrete/profiled metal deck composite floors
  - Frames and rafters to support slate roofs on the top of the building
  - Lift shaft frames, some of which may be visible (scenic) lifts.

The principle stability elements for the WRB are the masonry cross and spine walls. These must resist not only wind and "notional" horizontal loads but also the lateral arch thrusts from the Main Train Shed roof arches which are supported by the east wall of the WRB. Some of the new openings proposed through the existing walls interrupt the stability load paths and these openings are in places framed with steel frames with moment resisting connections at corners which will transmit lateral forces around the new opening. Elements of steel plan bracing are also introduced in certain areas to form part of the overall stability system.

- ii.) Design Drawings show all dimensions relevant to the steelwork. If electronic information is required, request this from the ER, who will provide it in Project Standard format (Microstation). Refer to working drawings for other elements, including the WCC roof working drawings for the interface between the WCC and the STS, to cladding working drawings to determine all the fixings required for cladding, and to other package working drawings which interface with the steelwork.
- iii.) Design the connections to BS 5950 and use methods in the SCI/BCSA green books wherever practical. Where Full Strength Welds are not Full Penetration Welds take account of any eccentricity between the welds and the connected part in the design of the connection.
- iv.) The factored forces, combinations and other requirements for the design of the connections are shown on the design drawings. Unless noted otherwise, the forces and moments are factored (Ultimate) values as defined by BS 5950.
- v.) Observe aesthetic, structural or clearance limits as described below, or referenced on the design drawings.
  - Overhead Line Electrification (OLE) at a voltage of 25kV is present over the rail ways. The design seeks to minimise the need for works over or near these lines. Undertake works so that no operations occur within 2.75m of these lines and so

that there is no risk of items toppling onto the OLE. Arrange "possession" periods with power off for works which must occur within this zone.

- The existing WRB and STS buildings are historic Grade 1 listed structures. All works which interface with the fabric of these structures require approval from English Heritage. In design of fixings, temporary works etc seek to minimise the extent of modification to the heritage fabric (for example, by using "Lindapter" fixings, etc). Ensure that Heritage approval is in place before commencing works. Prepare submissions of drawings, technical literature, method statements etc as required by English Heritage for approval by them.
  - Undertake all site measurements or surveys as required to confirm the dimensions and details of all new elements to be fabricated and installed, prior to commencing fabrication.
  - The WCC Mezzanine floor and canopy and the link bridge must be erected from the surface of the suspended ground level slab of the Northern Ticket Hall and below the level of the WCC roof steelwork. This will introduce restrictions on the type and size of lifting equipment (small mobile cranes are assumed) and also on working space.
  - Certain steelwork, for example the rafters over the old parcels yard, the frames to scenic lifts and some elements of stairs will be visible and an aesthetic finish is required to connections, welds, bolt assemblies and paintwork – refer to other clauses of this specification. Refer to the design drawings, and the Architectural Specifications and Design Drawings for particular aesthetic requirements.
- vi.) Temporary works assumed in the design are shown on the design drawings. In general these apply to the temporary support of the STS and WRB existing elements and not to the erection of the steelwork. The Contractor is solely responsible for the stability of all structural elements during construction and until they are fully completed. Submit detailed Works Package Plans outlining the erection strategies to be adopted, which fully describe the temporary The Contractor is solely responsible for the stability of all structural elements during construction and until they are fully completed. Submit detailed Works Package Plans outlining the erection strategies to be adopted, which fully describe the temporary works/propping systems required to maintain stability and to achieve tolerances at the interface with cladding elements during construction.
- vii.) Provide the following for review by and acceptance by the ER (in addition to items referred to in clauses 3.6.2 and 8.1.1):
- A programme for receipt and review of submissions from the contractor, which is to be agreed with the ER. Allow time is this programme for review of any re-submissions required as a result of the ER's comments. Show on the programme activities for the preparation of submissions to English Heritage and other approving bodies, and allow time for review and acceptance by these bodies. Network Rail has particular requirements for the preparation and checking of designs for temporary works. Allow for these activities in the programme.
  - Details of the Examiner/ Examining Body that shows they comply with the requirements set out in the definition at the beginning of this project specification.
  - Procedures and qualifications of personnel to be used for the coordination of welding operations, referenced to BS EN 729.
  - Two weeks prior to the start of production, a Record that the Weld Procedure Specification sheets particular to the project with the appropriate Weld Procedure

Approval Records have been submitted to an accepted the Examiner/Examining Body.

- Manufacturer's technical literature for proprietary items to be used if different from those indicated on the design drawings (for example, profiled metal decking and paint systems).

- viii.) Development of plastic hinges is not assumed in the design (see 4.6.1).
- ix.) No dynamic or vibrating forces with fatigue effects are to be considered.
- x.) Steel designations are generally to be (see Table 2.1):

Open sections, plates and flats	Grade S275J0 or S355J0 to BS EN 10025
Closed sections	Grade S275J2H or S355J2H to BS EN 10210-1, hot-finished.

The design drawings indicate where different yield strengths are to be used. References to S275 or S355 on the design drawings must be taken to mean the particular designations tabulated above.

All material to harmonised European Standards (e.g. BS EN 10025) shall be CE marked.

- xi.) Where additions and stiffeners are required to develop the strength of the member or around services openings, these are shown on the design drawings. Certain elements are required to resist torsions and thus notching may affect member stability. The tables of connection design forces and symbols on the drawings show which members resist torsion. Elements which crank should be detailed with stiffeners through crank.
- xii.) See section 6 for grades of bolt assemblies and their coatings.
- xiii.) Details of the fixings or bolts to the foundations or walls designed by the ER are on the design drawings. Survey on site the location and condition of all existing holding down bolt assemblies and report any discrepancies to the ER, with proposals for resolution.
- xiv.) Use SBD 5-Star grout or similar approved under column base plates.
- xv.) Where there are particular design or aesthetic requirements for connections a design intent is shown on the design drawings. Undertake the residual design of these connections in accordance with the design intent, verifying the connection for the forces given on the design drawings and deciding on appropriate sizes for plates, bolts and welds etc. If wishing to propose a connection of a different form, submit sketches for approval by the ER. This submission is in addition to those defined in section 3.6.
- xvi.) Cutouts, holes or fittings will be required for use by others, including cladding restraints, balustrade fixings, access safety restraint points and building services attachment points. The Contractor shall review and coordinate the Working Drawings for all elements requiring fixings, restraints and attachments, and provide the items of steelwork required by them.
- xvii.) Camber and presets which have to be provided in fabrication of composite floor beams are shown on the design drawings.

The steel beams that support the tiled cladding to the WCC Mezzanine Canopy are required to achieve an erected geometry with tight limits on relative positions of adjacent elements. It is suggested that allowance be made for packing at

connections between the primary beams and the vertical support elements (columns and lift shaft) to allow for adjustments to the canopy steelwork to achieve these tolerances.

Describe in erection Works Package Plans how fabrication and erection tolerances will be achieved. Submit these to the ER for approval.

Table 1.3 Workmanship

- i.) There are no restrictions on hard stamping or other permanent forms of identification (see 4.1.3 ).
- ii.) Refer to section 5 for any special welding procedures (such as for non-standard joint types, or for restricted access situations) which have to be approved prior to the work commencing.
- iii.) Where fabrication or erection attachments (see 3.4.2 and 5.4.5) will be visible or will extend outside of the structural zone, consider the use of attachments that can be easily removed (for example, by removing bolts). Agree the form of any fixed or removable attachments of this nature with the ER prior to fabrication.
- iv.) No production test plates are required (see 5.4.7).
- v.) The scope of weld inspection is given in section 5.5M.
- vi.) Acceptance criteria for welds are given in section 5.5M..

Table 1.4 Erection

- i.) Refer to the ER for a site plan showing position of datum level and setting-out lines.
- ii.) Refer to the ER for width and level of the prepared working area, for access of Site traffic, access equipment and cranes, and areas available for storage (see 8.2).
- iii.) Refer to the ER for availability of site services and any prearranged procedures for cooperation with other contractors (see 8.3.1 and 8.5).
- iv.) Refer to the ER for any limitation on dimensions or weights of components to be delivered to the Site or ground capacity limits for heavy loads. Note also that erection of the WCC Mezzanine and the link bridge must be undertaken on top of the suspended ground level slab over the Northern Ticket Hall, which has a finite load capacity as given on the Northern Ticket Hall drawings, and will therefore limit the size of erection plant that can be used.
- v.) Design features which would affect the construction sequence, or which may create an unusual hazard during construction are described in (vii) below.
- vi.) Refer to the ER for details of any underground services, overhead cables or site obstructions. The presence of OLE cables is discussed above.
- vii.) Report ENG-REP-G5-OAP-006-SWNS-0025 *Construction Strategy Report* describes the method of erection envisaged by the Employer's designer, giving the sequence for erecting the structure taking into account any phasing of the Works. The contractor's attention is drawn to:
  - The assumption that the metal decking stabilises the top flange of "composite" steel beams during the temporary stage. Ensure that sufficient decking is in place and shear studs through-welded to restrain the top flanges before concreting.
  - The stability mechanisms for the permanent works as described in Table 1.2A above. Determine whether temporary works are required to stabilise the structure until a sufficient extent of connections with walls, floors or other non-steel stabilising structures are installed (in accordance with 8.4.1).

- No detailed as-built information is available for the STS and WRB structures. In order to develop the Package 6 design a number of assumptions have had to be made about the nature and arrangement of the existing structure. These are documented on the design drawings in the ENG-DWG-OAP-WRB-CXP-0000 series. Understand the limitations of the information on these drawings and the consequent risks to safety, cost and programme. Compare the assumptions on these drawings with the arrangements found on site. Report significant departures to the ER before proceeding with works.
- viii.) Refer to vii) above for a description of any temporary works and any special requirements. These are no longer necessary after the structural elements on the design drawings are complete, and are not required to be left in position after completion of the steelwork.
- ix.) The main contractor and the ER will define responsibilities at the interface between the steelwork and other trades.
- x.) See 8.3.1 for discussion of "Safe Site Handover" procedures so that the Steelwork Contractor can comply with Section 8 (see 8.3.1).

Table 1.5 Protective Treatment

- i.) Surface preparation requirements are as per section 10.2.
- ii.) Thickness and composition of any sprayed metal coatings are listed in the specification tables.
- iii.) Where shown on the design drawings, hot-dip galvanise steelwork to BS EN ISO 1461. Visually inspect all galvanized elements post-galvanizing to the level required by PGI-1 of table 10.1 (see 10.4). The inspector shall be suitably qualified for such inspections, and should be familiar with the fabrication details and possible crack initiation sites.
- iv.) Where shown on the design drawings, paint steelwork in accordance with the following specification table:

NOTE: PAINT SYSTEMS MUST COMPLY WITH THE NETWORK RAIL SPECIFICATION R.T.98 (Ref NR/SP/CIV/039).

Notation on design drawings	Surface preparation	Coatings					
		Primer [microns]		Barrier [microns]		Finish [microns]	
X-2	Blast clean SA2½	Epoxy Zinc Phosphate {7.1.2}	75	Epoxy MIO {7.2.1}	100	Acrylic/Urethane to Architect's specification* {7.3.1}	50
N-2	Blast clean SA2½	Epoxy zinc Phosphate {7.1.2}	75			Acrylic/Urethane to Architect's specification* {7.3.1}	50
N-3	Blast clean SA2½	Epoxy Zinc Rich {7.1.3}	75				
F-1	Blast clean SA2½	Epoxy zinc Phosphate {7.1.2}	75	Thin-film intumescent, DFT to give 60min fire resistance* {9.1}		Acrylic/Urethane to Architect's specification* {7.3.1}	50
F-2	Blast clean SA2½	Epoxy zinc Phosphate {7.1.2}	75	Site installed dry casing or sprayed fireproofing to architect's specification will be installed over the primed steelwork			

1. Blast cleaning shall be undertaken to BS7079 part A1.
  2. Numbers in {brackets} refer to clauses in Network Rail Specification R.T.98.
  3. All materials shall be supplied from a single manufacturer and applied in accordance with the manufacturers instructions.
  4. Zinc rich primers shall comply with BS4652.
  5. The thickness quoted are MINIMUM DRY FILM THICKNESS (DFT).
  6. All materials are to comply with the maximum Volatile Organic Content (VOC) given in the current edition of the Secretary of State's Process Guidance note PG 6/23.
  7. Finish coats marked \* to be site applied. Primer and barrier coats to be shop applied. Intumescent coats either site or shop applied to suit contractor's methods.
- v.) The Steelwork Contractor shall repair any damage to the coating to the same standard as the original specification.

- vi.) Requirements for fire protective coatings are covered in the specification tables in Table 1.5 (iv) above.

#### Table 1.6 Inspections and Tests

- i.) If surface flaw or ultrasonic examination are not independent of the steelwork contractor, additional examinations by an Inspection Authority shall be carried out. These examinations shall consist of five visits. Keep the IA informed of the progress of the work. The IA will not give notice of the visit.
- ii.) Give the IA two weeks advance notice of fabrication works commencing.

#### Table 1.7 Programme

- i.) Refer to the ER for date(s) of issue of the design drawings or data for construction and other information necessary for the progress of the Works.
- ii.) Refer to the ER for the period to be provided in the Steelwork Contractor's programme for acceptance of submitted information.
- iii.) Refer to the ER for the date(s) by which the Site is expected to be ready with foundations prepared, free from obstruction, and accessible; with working surfaces, access roads and storage areas prepared and services available.
- iv.) Refer to the ER for the proposed starting and completion dates for erection of steelwork and the dates when other contractors' activities are expected to interface with the steelwork erection programme.

## 2 MATERIALS

As NSSS.

## 3 INFORMATION PROVIDED BY THE STEELWORK CONTRACTOR

As NSSS apart from:

### 3.4.3M Welding

- i.) Any requirements for edge preparations for welds shall be indicated.
- ii.) Welding inspection requirements which differ from those specified in 5.5M shall be clearly indicated.
- iii.) Where any full strength weld consists of a partial penetration butt weld and superimposed fillet the fabrication information shall clearly show the dimensions of the nominated un-fused land within the weld to enable sizing by ultrasonic inspection.

## 4 WORKMANSHIP - GENERAL

As NSSS.

## 5 WORKMANSHIP - WELDING

The following clauses completely replace section 5.

### 5.1 General

Weld using a metal arc process in accordance with BS EN 1011-1 and BS EN 1011-2 as appropriate, together with clauses contained in this section.

The Steelwork Contractor's system for the management of welding shall meet the standard quality requirements as described in BS EN 3834-3. As a minimum, this requires that

welding coordination is undertaken by persons with technical knowledge as that described in BS EN ISO 3834-5 (Certified International Welding Technologist, IWT).

All welding documentation (welder qualifications, welding procedure qualification records, welding procedure specifications and associated work instructions) shall be reviewed for applicability by the person responsible for welding coordination.

Prepare joints in accordance with BS EN ISO 9692, parts 1 and 2. Take precautions to ensure cleanliness of the connection prior to welding.

## 5.2 Welder Qualification

### 5.2.1 Approval

Test welders to meet the requirements of EN 287. Pay attention to section 9, period of validity.

### 5.2.2 Certification

Have Welder approvals witnessed and approved by an Examiner/Examining Body who shall be an independent body accredited by UKAS (ISO 9001).

### 5.2.3 Validity

As required in EN 287, test welders within 2 years of the previous test (ultrasonic, radiographic) and keep the report with the welder's approval sheet. Re-test the welder every 4 years.

### 5.2.4 Limitations

Welders shall work within the stipulated limitations as given in EN 287 at all times. Welds completed by welders found to be working outside stated limitations may be required to be removed.

## 5.3 Welding Procedures

### 5.3.1 Approval of Welding Procedures

Welding procedure trials shall be witnessed and approved by an Examiner/Examining Body and be in accordance with BS EN ISO 15614. Witnessing of procedures shall be undertaken by approved inspectors (PCN, EN 473) as a minimum and approval by an approved technologist (certified IWT) as a minimum. Approvals may be previously qualified and/or approved to BS 4870 and EN 288. Where required in section 3 (see 1.2(vii)) they shall be submitted for review by the Employer's Representative at least 2 weeks prior to the start of production. Documents required to support a welding procedure qualification record are as follows:

#### WPQR

Complete mechanical test results

Complete non-destructive test results

Original material certificates (which should have either a full chemical analysis or the carbon equivalent)

Consumable certificates (if available)

Summary documents are not acceptable.

*Note: Testing as detailed in the application standard does not provide information on mechanical properties of joints in fillet welds, partial penetration welds, tee butts or full strength welds. Where these properties are relevant to the application, an additional approval shall also be held e.g. a butt weld approval.*

*Notified fillet welds, partial penetration welds, full strength butt welds and tee butt welds subject to tensile loads > 0.5 Ys; tests shall be completed by additional cruciform test performed in accordance with EN ISO 9018.*



### 5.3.2 Preparation for Procedure Specifications

Formal welding procedure specifications (WPSs) shall be available in accordance with BS EN ISO 15609. They shall comply with the guidance of BS EN 1011-2, Annex C, Method A in the avoidance of hydrogen cracking. Consideration shall be made of the requirements in Annex D to ensure that there is adequate toughness in the heat affected zone of the weld (HAZ). HAZ toughness shall as a minimum be equivalent to the parent steel specification. Generic work instructions are not acceptable.

All WPSs shall be approved by the welding coordinator (IWT) before being used in production. Where WPSs are based on previously approved WPQRs they shall be submitted to the Examiner/Examining Body for verification of compliance with EN 15614 and EN 1011. WPSs shall be made available to the Employer's Representative or Inspection Authority on request.

*Note: The suitability of WPSs for the steel to be welded includes the consideration of the actual carbon equivalent of the steel if this differs from the value (CE) recorded in the WPQR.*

### 5.3.3 Application of Welding Procedure Specifications

Formal job specific WPSs shall be available to the welder or operator prior to commencement of works.

## 5.4 Assembly

### 5.4.1 Fit-up

Joints shall be fitted up to the dimensional accuracy required by the welding procedure, depending on the process used, to ensure that the quality in Table C.1 and C.2 in Annex C of the National Structural Steelwork Specification, 5<sup>th</sup> Edition is satisfied.

### 5.4.2 Jigs

Fabrications assembled in jigs may be completely welded in the jig, or may be removed from the jig after tack welding. It is the responsibility of the Contractor to ensure the welds used before removal are adequate.

### 5.4.3 Tack Welds

Tack welding may be used provided:

They are laid in the area to be welded and are thoroughly removed by grinding or gouging such that the subsequent welding is unaffected; or,

They are undertaken by a welder approved as in 5.2 as short length normal welds at least four times the thickness of the thicker part being joined, or 50mm whichever is the greater and the procedure shall comply with 5.3; or,

They are undertaken by a welder approved to 5.2, to a welding procedure that complies with 5.3, and the tack is fully re-melted during subsequent welding (this will need to be substantiated by a welding procedure).

### 5.4.4 Distortion Control

The sequence of welding a joint or a sequence of joints shall be such that distortion is controlled and minimised and specified limits not exceeded (see section 7, National Structural Steelwork Specification, 5<sup>th</sup> Edition).

### 5.4.5 Fabrication or Erection Attachments

Welding of attachments required for fabrication or erection shall be made in accordance with the requirements for a permanent weld and inspected.

When removal is necessary, they shall be flame cut or gouged at a point not closer than 3mm from the surface of the parent material. The residual material may be ground flush and the affected area visually inspected. When the base material exceeds 20mm (or carbon

equivalent > than 0.43%) it shall also be checked by magnetic particle inspection.  
Attachments shall not be removed by hammering.

#### 5.4.6 Extension Pieces

Where the profile of the weld is maintained to the free end of a run by the use of extension pieces they shall be of material of similar composition, but not necessarily the same grade. They shall be arranged to provide continuity of preparation and shall be removed after completion of the weld and the end surface ground smooth.

#### 5.4.7 Production Test Plates

Where production test plates are specified for test purposes they shall be clamped in line with the joint. The grade of material, carbon equivalent and rolling direction shall match the parent plate, but need not be cut from the same plate or cast.

### 5.5 Non-destructive Testing of Welds

#### 5.5.1 Scope of Inspection

Category A is the default level unless otherwise specified.

Table A – Scope of Inspection						
Weld Type	Category A Inspection			Category B Inspection		
	Visual	MPI	Ultrasonic	Visual	MPI	Ultrasonic
FPBW	100%	100% first 5 of weld type, then 50% thereafter.	Material thickness > 8mm 100% first 5 of weld type then 50%	100%	100% first 5 weld type, then 20%.	Material thickness > 8mm 100% first 5 of weld type then 20%
FSBW	100%	100% first 5 of weld type, then 50% thereafter.	Material thickness > 8mm 100% first 5 of weld type then 50%	100%	100% first 5 weld type, then 20%.	Material thickness > 8mm 100% first 5 of weld type then 20%
PPBW	100%	100% first 5 of weld type, then 20% thereafter.	Material thickness > 8mm 100% first 5 of weld type then 50%	100%	100% first 5 weld type, then 20%.	Material thickness > 8mm 100% first 5 of weld type then 10%
FW	100%	100% first 5 of weld type, then 20%, reducing to 10% of weld length to include start/stop zones.	Material thickness > 8mm, leg length > 12mm 100% first 5 of weld type then 10% of weld length	100%	100% first 5 of weld type, then 10%, reducing to 5% of weld length to include start/stop zones..	Not required

*Note: Site welds 100% inspection.*

Inspection levels may be reduced from the stated requirement in Table A at the Employer's Representative's discretion. This will only be considered where fabricators have adequate quality control and assurance systems in place and can demonstrate a prolonged period of continuity of quality. Under such circumstances the steelwork contractor may submit alternative inspection levels for review and approval by the Employer's Representative.

### 5.5.2 Information

The inspector or Inspection Company shall be provided with all information to enable inspection to be conducted and reported. This will include access to the contract specification, WPSs, material certificates (to verify grade), fabrication records (project identification). Inspection records that fail to be identified to the project or do not have the correct acceptance criteria stated will be rejected and all work re-inspected. It is the fabricators responsibility to ensure the inspector has the information required to perform his duties.

### 5.5.3 Record of Testing

The results of visual inspection, surface flaw detection and ultrasonic inspection shall be recorded and be available when requested. All defects shall be recorded in a repair register along with remedial actions and final close-out report to verify repair. Separate records for acceptable work and defective work are not acceptable.

### 5.5.4 Visual Inspection

Visual examination shall be made in accordance with EN 970, sections 8, 9 and 10 over the full length of the weld. Such inspections shall be performed before any required non-destructive inspection (to reduce time wastage) and results recorded.

A full inspection report shall be made for all inspections and shall record any defects on the same sheet as acceptable work. Fabrications and welds shall be clearly identified to enable traceability of any connections inspected. Identification of connections or welds should conform to the system adopted in the fabrication shop and should not be a separate system devised by the inspection company.

A suitably qualified person for visual inspection of welds may be a welding inspector or a welder who can provide evidence of having been trained and assessed for competence in visual inspection of the relevant types of welds during and after welding by a nationally recognised authority (TWI, PCN, CSWIP, EN 473). Internal company training schemes are not acceptable.

### 5.5.5 Surface Flaw Examination

Magnetic particle inspection (MPI) shall be in accordance with Table A and conform to the recommendations in BS EN 1290.

If MPI is impractical, dye penetrant inspection (DPI) may be used in accordance with the recommendation given in BS EN 571-1, with the permission of the Employer's Representative.

Final surface flaw detection of a welded joint shall be carried out after completion of the weld in accordance with the hold times given in Table B.

A full inspection report shall be made for all inspections and shall record any defects on the same report as acceptable work. Fabrications and welds shall be clearly identified to enable traceability of any connections inspected. Identification of connections or welds should conform to the system adopted in the fabrication shop and should not be a separate system devised by the inspection company.

A suitably qualified person for surface flaw detection of welds should be a welding inspector who holds a current certificate of competence from a nationally recognised authority that meets the requirements of EN 473 (PCN, CSWIP, EN 473).

### 5.5.6 Ultrasonic Examination

Where ultrasonic examination is required in accordance with Table A it shall be made in accordance with the requirements of BS EN 1714 using reference method 1, evaluation reference – 14dB (20% DAC) and examination level B and recorded on the inspection report. Evaluation reference -10 dB (33% DAC), as stated in EN 1714 will not be accepted.

Guidance for scans should be taken from BS 3923. Ultrasonic procedures developed to BS 3923 are acceptable.

Ultrasonic examination of the welded joint shall be carried out after completion of the weld in accordance with the hold times given in Table B.

A full inspection report shall be made for all inspections and shall record any defects on the same report as acceptable work. Fabrications and welds shall be clearly identified to enable traceability of any connections inspected. Identification of connections or welds should conform to the system adopted in the fabrication shop and should not be a separate system devised by the inspection company.

Inspectors carrying out ultrasonic examination shall hold a current certificate of competence from a nationally recognised authority that meets the requirements of EN 473 (PCN, CSWIP, EN 473).

*Note: In addition to weld examination, through-thickness ultrasonic examination of the parent material may also be necessary for weld geometries susceptible to lamellar tearing.*

Table B – Recommended Hold Times			
Material grade	Weld size	Heat input (kJ/mm)	Hold time (hours)
All grades covered by the specification unless notified otherwise on the design drawings (S275, S355, S420)	a or $s \leq 6$	All	Cooling period only
	$6 > a$ or $s \leq 12$	$\leq 3$	8
		$\geq 3$	16
	a or $s > 12$	$\leq 3$	16
		$\geq 3$	40
<p>(i) Size applies to the nominal throat thickness of a fillet weld (a), the nominal depth of a partial penetration weld, or the material thickness of a full penetration weld (s). For individual partial penetration butt welds the governing criterion is the nominal weld depth (a), but for pairs of partial penetration butt welds welded simultaneously it is the sum of the weld throats (a).</p> <p>(ii) Heat input (Q) to be calculated in accordance with clause 19 of BS EN 1011-1</p> <p>(iii) The time between weld completion and commencement of NDT shall be stated in the NDT report. In the case of “cooling period only” this will last until the weld has cooled to ambient temperature.</p>			
<p><i>Note: In certain situations hold times MAY need to be greater than shown. This is particularly important when considering weld metal hydrogen cracking of higher strength steels and cases where borderline conditions exist. This remains the responsibility of the Steelwork Contractor to determine.</i></p>			

#### 5.5.7 Acceptance Criteria and Corrective Action

Welds and adjacent material shall comply with BS EN ISO 5817, level C. For FSBW's and PPBW's the measured un-fused land shall not be a cause for rejection as long as they meet the minimum specified requirement for penetration.

All welds shall be repaired to meet the minimum requirements, a record kept and the Employer's Representative informed of serious defects (cracks, lamellar tears, incorrect weld type).

If cracking or lamellar tearing is located inspection should increase to 100% for the weld type and WPS. For less serious defects inspection of previous welds should be conducted to determine if the problem is more widespread (at least 2 welds). If further defects are located increase inspection to 100% of weld type using the same WPS and inform the Employer's Representative. Consideration should be made as to whether the defect is a procedural problem or welder induced. Repair will require a specific repair WPS which will need approval.

## 5.6 Shear Stud Welding

### i.) Method

Shear studs shall be welded in accordance with BS EN 14555:1998 and the manufacturer's recommendations for materials, procedures and equipment. Adequate return earth connections shall be made local to the area being stud welded.

If the studs are to be welded by other than drawn arc and this has not been indicated on the design drawings, the Employer's Representative shall be notified. Unless agreed otherwise, the size of fillet weld shall be chosen such that the full tension capacity of the stud can be developed.

The local area around where the stud is to be welded shall be free of standing water before commencement of welding.

*Note: See the BCSA Code of Practice for Metal Decking and Stud Welding for further guidance.*

### ii.) Trial Welding

At the start of each shift when stud welding is in progress each welder shall perform the fixing of at least two trial studs. If either of these trial studs fails a bend test in accordance with the following clause, then further trials shall be conducted until satisfactory performance is established.

### iii.) Tests and Inspection

All studs are to be visually inspected and ring tested. Studs shall be replaced if they show less than a full 360° collar of weld or if they do not give a clear ring when struck with a metal club hammer.

After satisfactory visual inspection and ring testing, bend tests shall be made at locations agreed with the Employer's Representative. A minimum of 5% of the studs, but not less than two studs per beam shall be tested by bending the head of the stud towards the nearer end of the beam.

The bend test shall be by means of a steel tube placed over a stud and bending the head until it is displaced laterally a distance of one quarter of the height of the stud (at least 15°). The stud weld shall not show any signs of cracking or lack of fusion.

Studs subjected to the bend test shall not be straightened.

### iv.) Defective Studs

Studs with defective welding shall be replaced with a new stud in an adjacent location. The replacement stud shall be re-tested as in 5.6. Inspection shall increase to 5 adjacent studs, if further failures are found the cause shall be determined before resuming welding. The defective stud need not be removed.

If it is necessary to remove the defective stud it shall be detached and, where the flange is subject to tension, the surface ground and checked for cracks using the methods described in 5.5.5.

## 6 WORKMANSHIP - BOLTING

As NSSS.

## 7 WORKMANSHIP - ACCURACY OF FABRICATION

As NSSS.

## 8 WORKMANSHIP - ERECTION

As NSSS.

## 9 WORKMANSHIP - ACCURACY OF ERECTED STEELWORK

As NSSS except the following:

### 9.4M Deviations

The Steelwork Contractor shall as soon as possible inform the Employer's Representative of any deviation in position of erected steelwork which is greater than the permitted deviation in 9.6 so that the effect can be evaluated and a decision reached on whether remedial work is needed.

Where it is necessary to combine permitted deviations to establish the acceptability of the position of the steelwork the deviations shall be combined using the root sum square method.

### 9.6.19(A)

Members other than columns shall not deviate from their specified position relative to the adjacent columns by more than 5mm.

## 10 PROTECTIVE TREATMENT

As NSSS.

## 11 QUALITY ASSURANCE

As NSSS.

### ANNEX A

This Annex is replaced by table B in section 5M.

### ANNEX B

This Annex is replaced by table A in section 5M.

### ANNEX C

Defect acceptance criteria for non-destructive testing of welds are to be as set out in 5.5.7M rather than this Annex.

### ANNEX D

EN 970 is to be used in place of this Annex.

### ANNEX E

The table is to be amended as follows:

The primer thickness for specifications I-2 and I-3 is to be 75microns.

The specification in the last line of the table is to be labelled I-5 rather than E-2.

The notes are to be amended as follows:

Note (2) M      **Minimum** dry film thickness in microns.