Engineering Specification Cover Sheet

Part Name: FRAME-SUBFRAME ASSEMBLY (DETAIL NOTES)- WELD REQUIREMENTS	Part Number:ESBC34-5005-AB (v2)

LET																								
FR																								
LET																								
FR																								

Date	LET	FR	Revisions	DR	CK
20110615			RELEASED New (Replaces ESBC34-5005-		DLH
			AA dated 01/2011)		
			Multiple: References corrected /		
			updated		
			Multiple: Verbiage updates		
		2	Added: Table of Contents		
		5	Added: stops and starts should be		
			depicted		
		9 &	Root of Joint and Joint Root common		
		10	ized to Joint Root		

Reference: ESBC34-5005-AA

Prepared/Approved By:
D. L. HOWE

Checked By:	**Detailed By:**

Concurrence/Approval Signatures:

Design Engineering Supervisor
Dan McCarthy

Design Engineering Manager
John Caris

Other Approvals /Concurrences (as required)

Purchasing
Adam Golden
Jae Bae

STA Welding & Joining
Brian Hable
Sunita Shahmehri
Travis Cruzan

STANDARD NOTES:
FOR CURRENT RELEASE STATUS, SEE THE WERS ENGINEERING NOTICE.

▽ CONTROL ITEM – THE ▽ ALSO IDENTIFIES CRITICAL CHARACTERISTICS DESIGNATED BY THE CROSS FUNCTIONAL TEAMS DEVELOPING THE PRODUCT. THESE, AND ADDITIONAL CRITICAL CHARACTERISTICS IDENTIFIED BY PROCESS REVIEWS, MUST APPEAR ON THE CONTROL PLANS ACCORDING TO ISO/TS 16949. THESE CONTROL PLANS REQUIRE PRODUCT ENGINEERING APPROVAL.

Table of Contents

I. GENERAL

A. SCOPE

1. This specification defines the Quality and Reliability (QR) weld fabrication requirements in completed vehicle frame assemblies constructed of steels up to and including nominal yield strengths of 1100 MPa, and gages of 1 to 15 mm. It is understood that this full document may not apply. "Exceptions" to this document should be detailed on the Ford or Supplier Final Release Print(s) under the Welding ES callout: "WELD MUST CONFORM TO ESBC34-5005-AA. EXCEPT …". An alternative to this may be to document, as part of the callout: "WELD MUST CONFORM TO ESBC34-5005-AA, EXCEPTIONS LISTED ON AN EXCEPTIONS PAGE. SEE DCP AND CONTROL PLAN..

2. "This Engineering Specification is a supplement to the released drawing on the affected part, and all requirements herein must be met in addition to all other requirements of the part drawing."

3. "The Engineering Specification is intended to evaluate specific characteristics as a supplement to normal material inspections, dimensional checking, and in-process controls, and should in no way adversely influence other inspection operations."

4. "Preparation and submission of an acceptable Control Plan are the responsibility of the manufacturing source. The manufacturing source will retain the original Control Plan and any later revisions per QS-9000 and provide a copy to the design responsible Product Engineering activity."

5. For other Product Development or Supplier Engineering Sources: This document may be used in whole or in part, as a guideline for commodities other than framed/subframed vehicles.

6. Definitions of welding terms, procedures and defects are governed by those given in the American Welding Society's (AWS) publication AWS A3.0—2001 "Welding Terms and Definitions". Other references to be used in weld fabrication are:
   - AWS D8.8-2007 - Specification for Automotive and Light Truck Components Weld Quality - Steel Arc Welding (SAE JSH-1196)
   - AWS D1.3-98 - Structural Welding Code - Sheet Steel
   - AWS D9.1M/D 9.1-2000 - Specification for Welding of Sheet Metal
   - VOPSSN-008 - Weld Quality Program-Spot Weld Classification & Vehicle Operations Manufacturing Engineering Quality Policy Letter L-4 (use of Ultrasonic Testing for RSW attachments)
   - VOPSSN-018 – Assembly Tool Certification and Weld Specification.
   - ISO 2553:1992(E).
   - Ford W Series fastener standards (E.G. WE500, WE501, and WE960).

   The supplier shall have available in his plant's Quality Control, Manufacturing, Engineering, and Product Testing Offices copies of the above publications which are applicable.

I. GENERAL A, (cont.)

Note: The following documents, or latest version, should be added to the frame detail when applicable to avoid any issue(s) between Suppliers and Ford.
Note: One document does not cover all welding for a multi-component assembly and/or sub-assembly. The effect of parts in assemblies (PIAs) shall be reviewed (levels may be superseded, always ensure the latest document is used).

E.G. If ESBC34-5005-AA is used for frames that have studs and nuts that are projection and or arc welded, the proper, additional documents listed (below) need to be included on the detail to ensure full compliance.

GMAW (Body, thin gauges - .7 – 3.0 mm)……..ESBM5A-1B310-A_
Drawn Arc Welding of Studs, Nuts, and Brackets…….ESBM5A-1A332-A_
Projection Welding of Nuts and Bolts……ESBM5A-1N265-A_
Resistance Spot Welding. . . . . ESBM5A-1N261-A_
Arc Weld Studs ES-N807948-S5-
Fusion Fillet Welding . . . . . ES-C8AB-11006-A_
Material and Performance Requirements of Weld Bolts. .WA 960
Material and Performance Requirements of Weld Nuts. . WE 960

7. In case of any conflict between these publications:
- the Ford Released Engineering Assembly Detail (E.G. 5005) is the governing document
- the Ford Released Engineering Part (Component) Detail is second (Supplier component details will not take precedence over Ford requirements).
- exception(s) to this Engineering Specification is third,
- this Engineering Specification is fourth, and
- reference documents are fifth.

B. DESIGN CONSIDERATIONS

1. Complex Joints

1.1 Weld edges of multiple layers, especially where welded on both sides, shall be held per I. GENERAL, H. WELD QUALITY REQUIREMENTS, 1.4.4. Maximum allowable part gap …, (Ref: Figures 1 and 2), of this document.

1.2. Joints with more than one surface of attaching (E.G. a lap joint beside a T joint) must be controlled for appropriate weld gaps. If the trim tolerance on the T joint is +/- .25 mm, the lap joint must be held per I. GENERAL, H. WELD QUALITY REQUIREMENTS, 1. 4.4. Maximum allowable part gap …, of the T joint surface. (Figure 2)

2. Joint Integrity

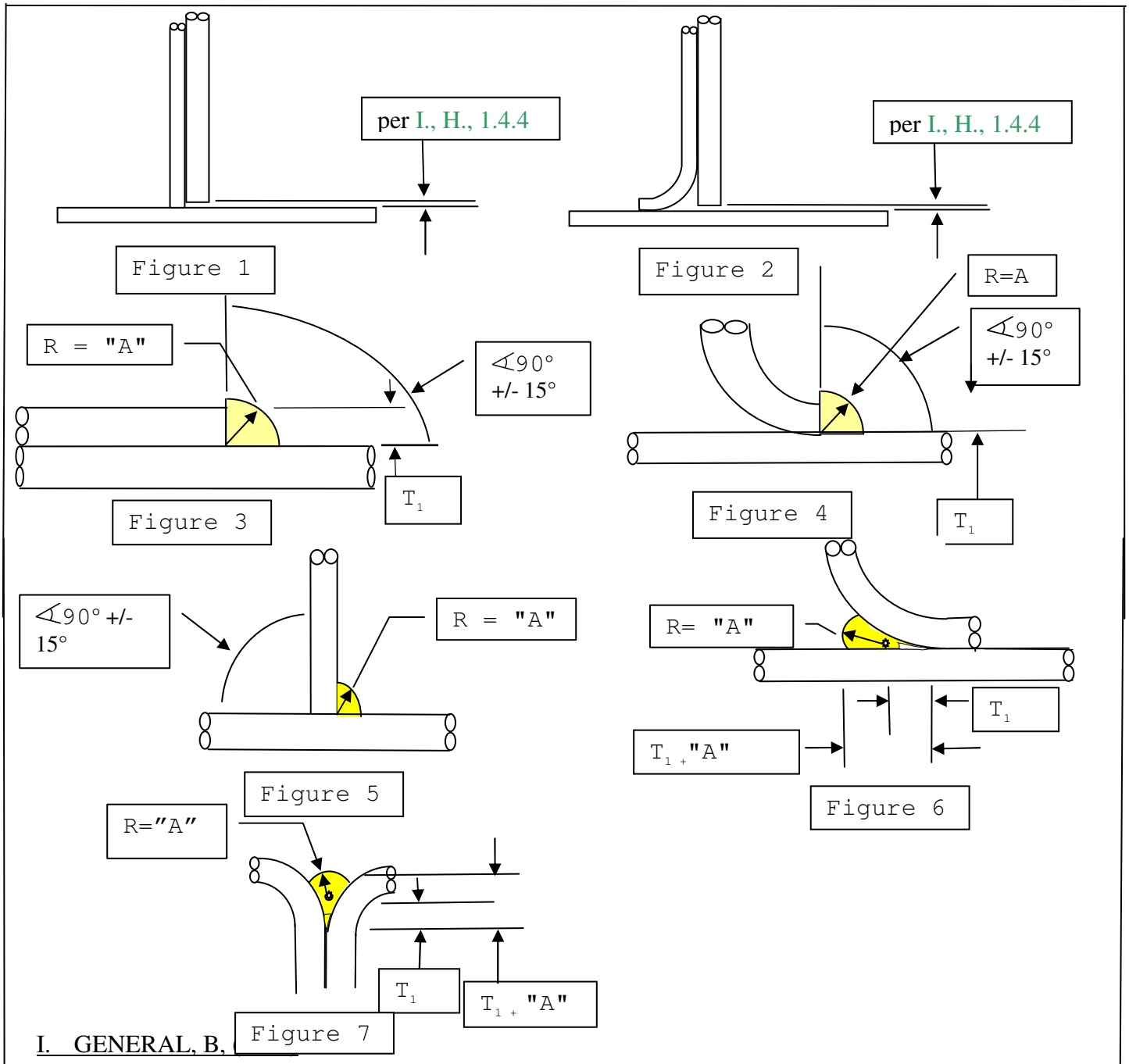
2.1 Joints should be designed so the relative angle is 90° +/- 15° to perpendicular. (Figures 3 through 5)

3. Weld Depiction and Callout (Part detail)

3.1 All welds are to be depicted including tack and temporary on all Ford CAD models and details (e. g. -5005- sheet 2) [includes CAD data provided by suppliers].

3.2 Weld starts and stops should be depicted.

3.3 Weld fill will be depicted as shown (ref: Figures 3 through 7). Depictions reflect actual weld plus a clearance allowance. See box below figure 7.



I. GENERAL, B,

T_1 = Thickness 1 – smallest (per ES)
T_2 = Thickness 2

"A" is the greater of 5.0 mm or T_1

3.4 Weld symbols and callouts are to be per Ford Engineering CAD & Drafting Standards D-3 "Welding Symbols and Definitions" (ref: http://www.fecds.ford.com/)

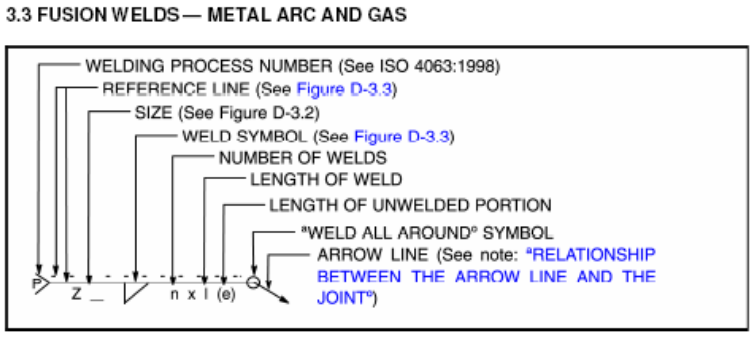
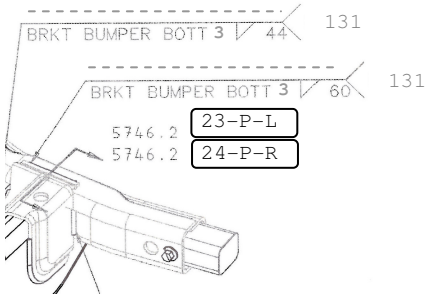


Figure D–3.1
(Ref: Ford CAD Standard D-3 v 22)



Typical Frame Weld Callout Format (includes weld sectioning depiction for "P" class weld)

4. Supplier Section Inspections / Weld Identification

4.1. For all identified frame welds, the supplier will perform weld section and etch analysis (supplemented with root bend or crush for G_B class welds) to demonstrate compliance with Section I. GENERAL, H. Weld Quality Requirements. The section locations are identified and numbered on the frame assembly drawing as follows:

N-P-L/R ——— where:

N Identifies individual number of weld section. "**P**" welds should be identified and numbered first, followed by "**G**" and "**G_B**" class welds in order of 'priority'.

P/G/G_B: Designates classification (per I. GENERAL, I. WELD CLASSIFICATION / ANALYSIS.) ("P", "G", or "G_B"). May be omitted for "G" class welds (must be present for "P" or "G_B" class welds).

L/R/B: may be used to designate if only left side [L] and/or right side [R] of frame weld section and/or both [B] weld sections are required. If not called out, assumed to be both sides of the frame where geometry is symmetrical or mirror image.

—-- or ⌐¬: Bar or section line (with arrows pointing to side of weld section to be reviewed) drawn thru weld represents cut section location.

I. GENERAL, (cont.)

C. OPERATOR QUALIFICATION

1. All welders or operators permitted to weld on a frame shall be first qualified by both test and training.

2. Where applicable Part A – Arc Welding, 4. Qualification of Arc Welders and Arc Welding Operators of AWS D9.1-2000 shall apply. An exception being that the welder shall be qualified on the thinnest material thickness that he will be required to weld.

3. Supplier shall submit his program for welder qualification and training to Ford Engineering and STA prior to the start of production.

4. The training program shall include the theory of the welding, the welding process to be used, definitions, cause of welding defects, and Ford's expected level of weld quality as defined in this specification.

D. WELDING PROCESSES

1. The mode of operation shall be limited to Automatic, Semi-Automatic, or Manual welding (Ref: I. GENERAL, F. WELDING TERMS, 1. Welding Types of this document). The use of Laser seam tracking devices is permissible when supported by metallographic evidence (cut and etch). The welding processes used shall be limited to the following:
   - Gas Metal Arc Welding (GMAW i.e. MIG [Metal Inert Gas])
   - Flux Cored Arc Welding (FCAW)
   - Submerged Arc Welding (SAW)
   - Arc spot welding in conjunction with any of the above processes.

   Exceptions: The following are additionally approved for repair only:
   - If used as a burn-through spot weld, a clamping pressure system must be incorporated in the welding gun.
   - Gas Tungsten Arc Welding (GTAW i.e. HeliArc)
   - Shielded Metal Arc Welding (SMAW i.e. STICK Welding) with prior approval by Ford Engineering and STA.

2. Semi-Automatic welding processes shall be subject to these guidelines.

2.1. All welds whose start or termination are to be held to a ±6.0 mm or (±0.24"), or less, are to be made in a positive locating fixture to ensure their location.

2.2. Wire feed adjustments and voltages are to be secured and/or controlled so that they cannot be changed, except by designated personnel.

2.3. The welding control is to be of a design that provides a digital readout of both arc voltage and wire feed speed.

I. GENERAL, D, (cont.)

2.4. Welding to be performed in the down-hand or horizontal plane ±15° for a minimum of 90% of the weld length required (except for tack welds).

E. . TYPE OF WELD JOINTS

1. Fillet Weld

A fillet weld is approximately triangular in cross section and joins the edge of one member to the surface of the adjacent member. Examples of acceptable sections for frame assemblies are shown below (Figures 8 – 12):

LAP JOINT

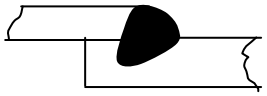


Figure 8

LAP JOINT

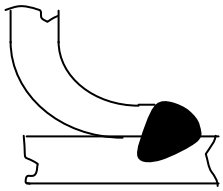


Figure 9

T-JOINT

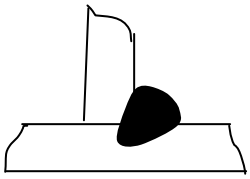


Figure 10

2. Groove Weld – NOTE: Groove Welds are not considered structural (Evaluate in CAE as if not present).

FLARE BEVEL

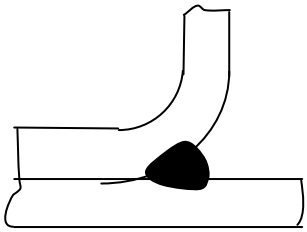


Figure 11

FLARE-V

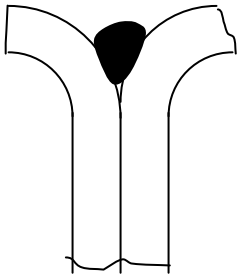


Figure 12

F. WELDING TERMS (REFERENCE FIGURES 13 THROUGH 16)

1. Welding Types

1.1. Manual:
SMAW (STICK) or GTAW (TIG)

1.2. Semi-Automatic:
Human held gun with automatic wire feed, voltage and gas

1.3. Automatic:
Fully Robotic with fixed automation.

I. GENERAL, F, (cont.)

2. The following definitions are referenced from American Welding Society publication AWS A3.0-2001, unless otherwise specified.

2.1. Weld Length (effective):
The length of weld between a start and stop throughout which the correctly proportioned cross-section exists. The minimum length of a structural weld is 25.0 mm, (which gives an effective weld length of about 13.0 mm). A weld of less than 25.0 mm (13.0 mm effective weld length) is considered a tack weld (Engineering Specification Definition).

2.2. Fusion Zone:
The area of base metal melted as determined on the cross section of the weld.

2.3. Gap:
The distance or airspace between two base components at the root of the joint to be welded (Engineering Specification Definition).

2.4. Joint Penetration:
The distance the weld metal extends from the weld face into a joint, exclusive of weld reinforcement.

2.5. Overlap:
2.5.1. Overlap-$_W$: protrusion of weld metal beyond the toe, or roots of the weld or
2.5.2. Overlap-$_L$: portion of the preceding weld nugget remelted by the succeeding weld.

2.6. Joint Root - (Theoretical):
That portion of a joint to be welded where the members approach closest to each other. In cross section, the root of the joint may be a point, a line, or an area.

2.7. Root Penetration:
The distance the weld metal extends into the joint root measured from the theoretical to the weld root (actual). (Engineering Specification Definition)

2.8. Skip:
An un-welded portion of a designated weld (AWS D8.8-2007).

2.9. Spatter:
The metal particles expelled during fusion welding that do not form a part of the weld.

2.10. Thickness of Welded Parts T_1 and T_2:
The thinner part has thickness T_1 and the thicker part has thickness T_2 in a welded joint. (Engineering Specification Definition).

2.11. Throat – Actual Throat

I... GENERAL, F, (cont.)

2.12. The shortest distance between the weld root and the face of a fillet weld

2.13. Throat – Effective Throat
The minimum distance from the fillet weld face, minus any convexity, and the weld root.

2.14. Throat - Theoretical Throat:
The distance from the beginning of the joint root perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the cross section of a fillet weld. This dimension is based on the assumption that the root opening is equal to zero.

.

2.15. Weld Back (Ref: :V. INSTRUCTIONS AND NOTES., Addendum IV):
Welding direction reversed and overlapped at the end of the weld to effectively increase the weld penetration locally.

2.16. Weld Face:
The exposed surface of a weld on the side from which welding was done.

2.17. Weld Leg (L_1, L_2 in figures 13 – 16) L_1 is on the part of T_1 thickness :
The distance from the Joint Root (theoretical) to the toe of the weld not including the gap (Engineering Specification Definition).

2.18. Weld Past (Weld By) (Ref:V. INSTRUCTIONS AND NOTES., Addendum IV):
Welding continued beyond the point of adjacency of the pieces being welded together.

2.19. Weld Root - (Actual):
The points, as shown in cross section, at which the back of the weld intersects the base metal. (Engineering Specification Definition).

2.20. Weld Toes:
The junctions between the weld face and the base metal welded surface.

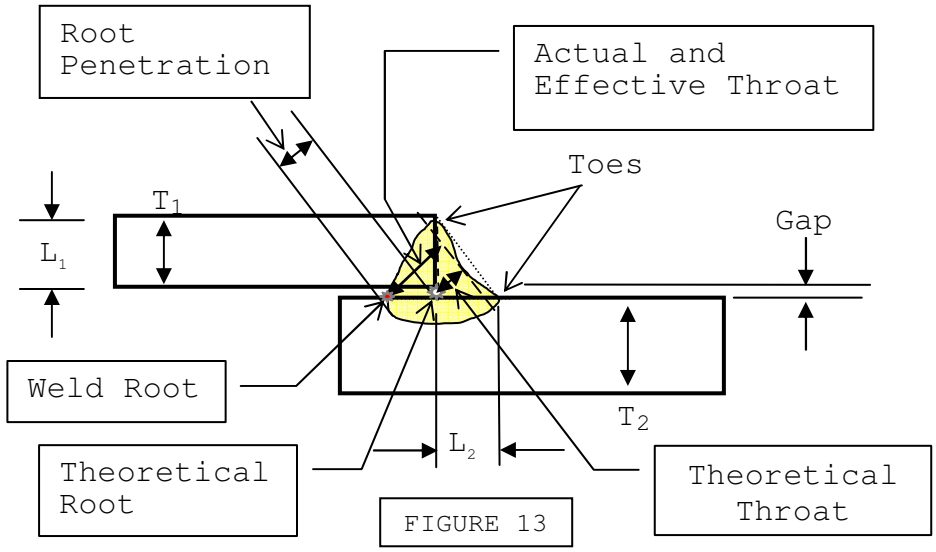


FIGURE 13

I... GENERAL, F, (cont.)

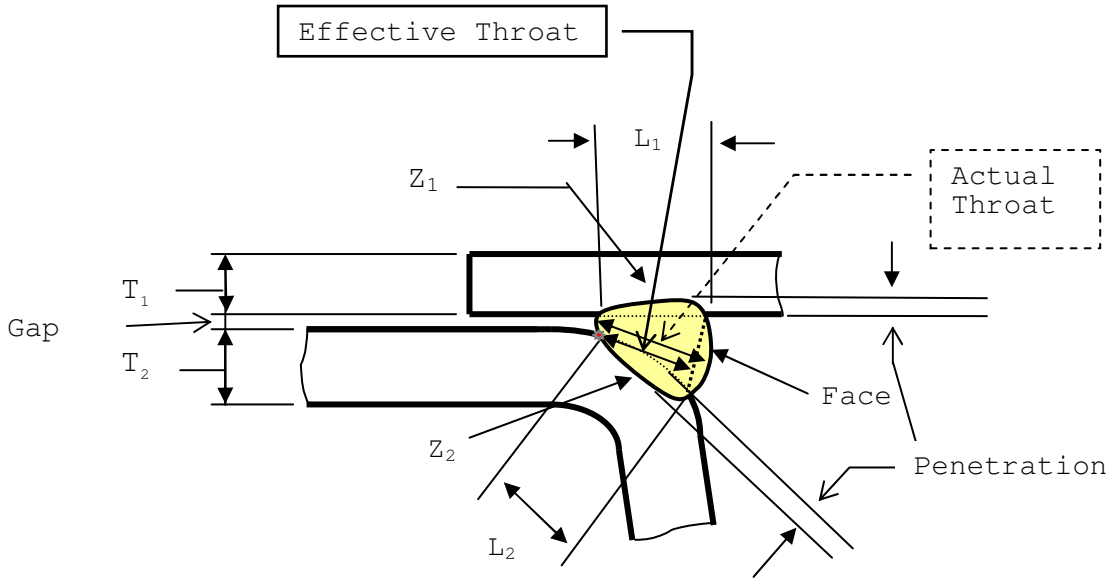


FIGURE 14

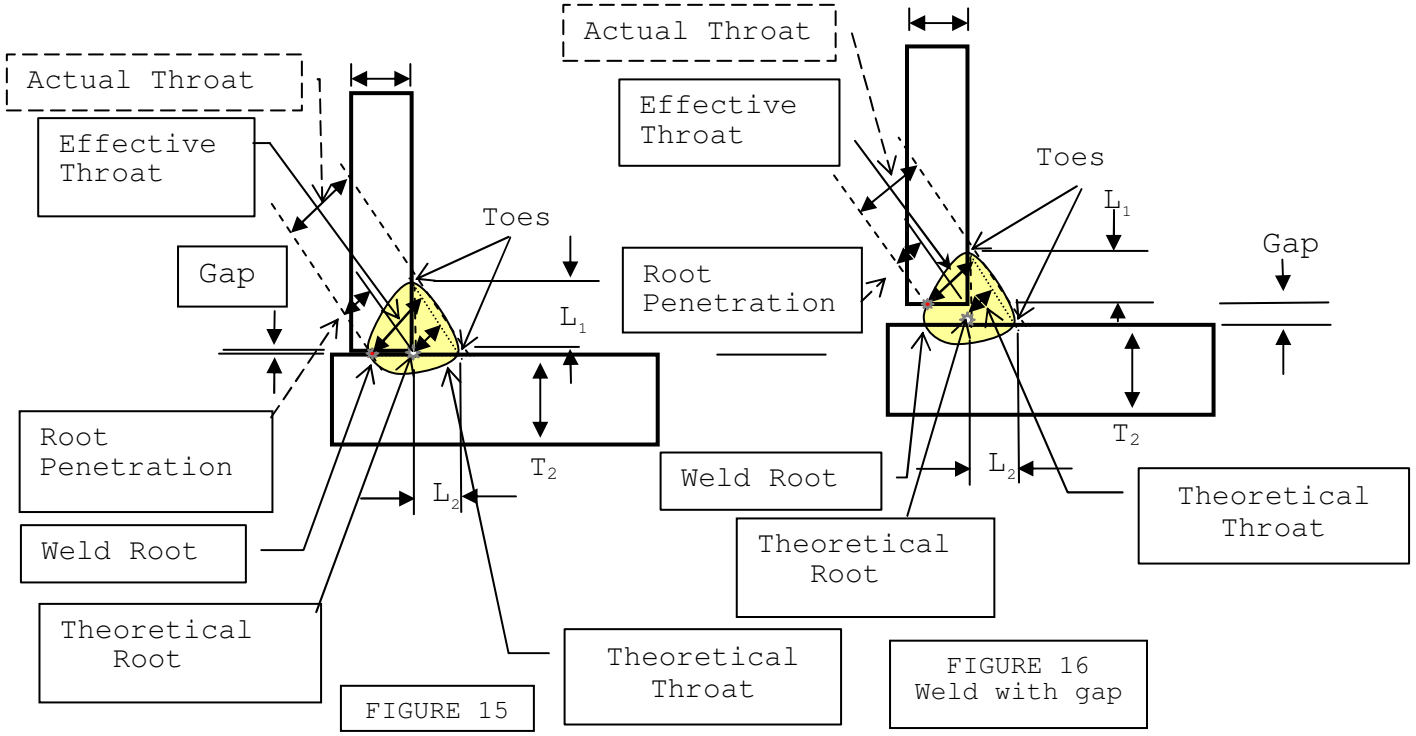


FIGURE 15

FIGURE 16
Weld with gap

G. WELD LENGTH DEFECTS (REFER TO FIGURES 17 TO 22)

1. Definitions are from American Welding Society publication AWS 3.0-2001, unless otherwise designated. Types of defects are:

1.1. Melt Thru:
The protrusion of metal through the base metal surface opposite the weld joint

location. (Engineering Specification definition).

1.2. Burn Thru:
Holes burned completely through the weld joint and/or base metal. (Engineering Specification definition).

1.3. Undercut:
A groove melted into the base metal adjacent to the weld toe or weld root and left unfilled by weld metal.

1.4. Meltback:
This occurs where the base metal melts back from the edge but does not become part of the weld. This condition leaves a void between the weld deposit and the base metal. (Ref: AWS D8.8-2007).

1.5. Crater:
A depression at the termination of a weld bead(s) or in the molten weld pool. (Ref: AWS D8.8-2007).

1.6. Weld Crack:
A fracture type discontinuity characterized by a sharp tip and high ratio of length & width to opening displacement. (Ref: AWS D8.8-2007).

1.7. Porosity:
Cavity type discontinuities formed by gas entrapment during solidification or in a thermal spray deposit. (Ref: AWS D8.8-2007).

1.8. Inclusions:
Shall be considered and judged as being porosity (Ref: AWS D8.8-2007).

1.9. Notching:
Gouging of the parent metal at the ends or edge of the welded joint (Ref: AWS D8.8-2007).

1.10. Arc Strike:
A discontinuity resulting from an arc, consisting of any localized re-melted metal, heat-affected metal, or change in the surface profile of any metal object.

I. GENERAL G, (cont.)

Some defect types shown below in FIGURES 17 through 22

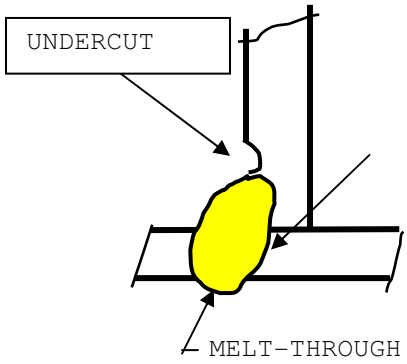


FIGURE 17

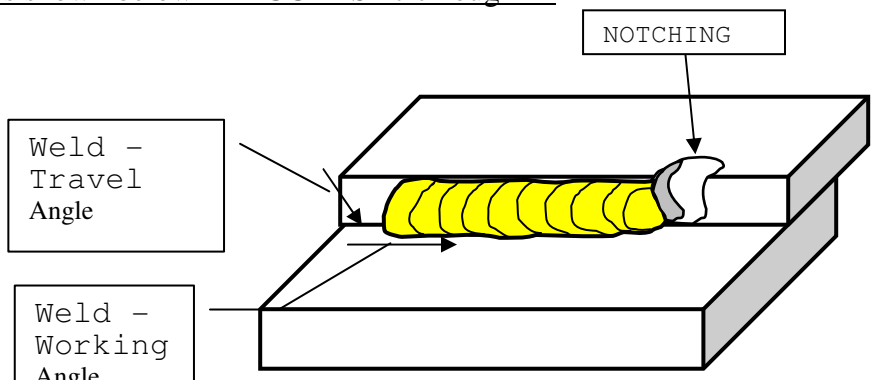


FIGURE 18

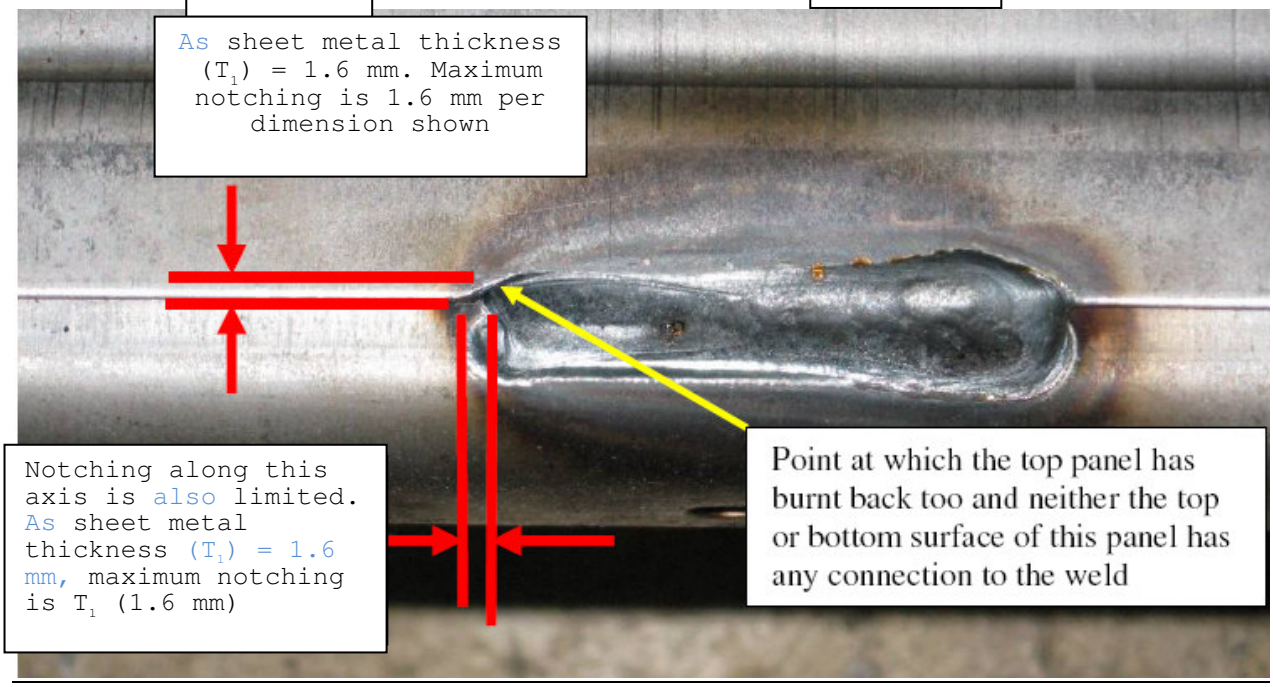


Figure 19

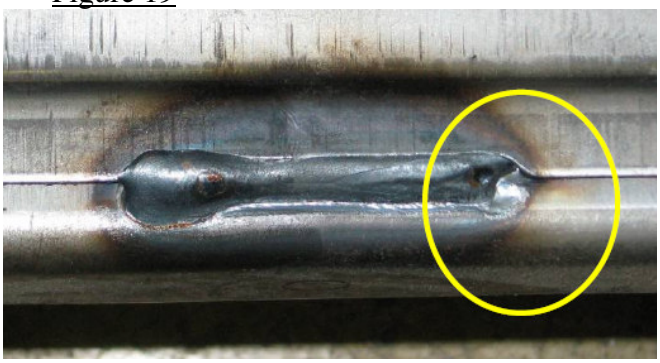


Figure 20

Bad weld – notching is greater than T_1 (1.6 mm in example)

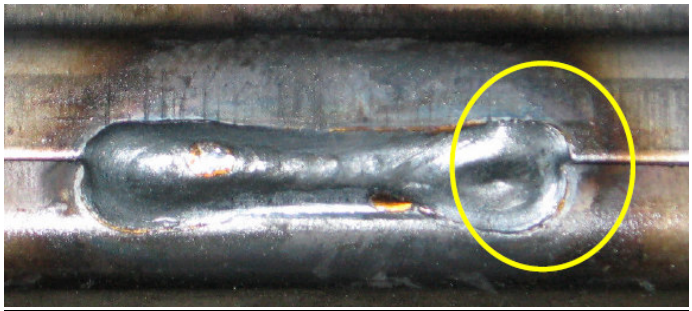


Figure 21

Good weld; notching is less than T_1

I. GENERAL, G, (cont.)

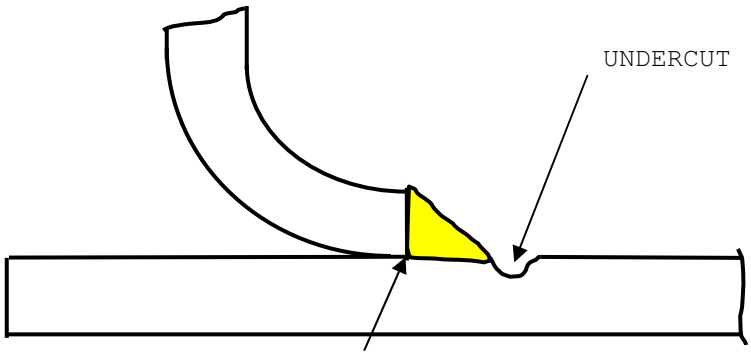


FIGURE 22

H. WELD QUALITY REQUIREMENTS

1. All welding per this specification shall meet the quality requirements listed below. Refer to Sections IV.REVALIDATION REQUIREMENTS, B. Corrective Action and C. Weld Repair Procedure for allowable repair procedures to meet weld quality requirements, and/or Ford Engineering and STA approved Control Plan or Repair Procedures.

1.1 Welded Sub-Assemblies

1.1.1. It is the supplier's responsibility that sub-assemblies must conform to the requirements in this document.

1.1.2. All PIA welds either produced at the supplier's facility, or their supplier's are subject to this document and the weld ESs noted in section I.

1.2 Weld Quality Requirements

1.2.1. Any lubricant, surface grease, oil, and other weld contaminants that are detrimental to welding as defined by this weld specification must be removed prior to welding (e.g. lubricants shall not increase the probability of spatter, burn through, etc.). Any change of lubricant shall be verified per table 5. Weld Changes / Actions below or engineering and STA will be notified (e.g. voltage / current change is less than 5%).

1.3 Weld Length Qualities

1.3.1. Melt Thru - not to exceed 130%T_1 unless otherwise designated on drawing.

1.3.2. Burn Thru - none permitted.

1.3.3. Maximum undercut in each weld length

I. GENERAL H, (cont.)

1.3.3.1. First and last 13mm (.50 in), 10% T_1

1.3.3.2. Remainder of length, 20% T_1

1.3.4. Meltback – not acceptable in gauges (T_1) less than 2.3 mm.

1.3.4.1. For gages of .2.3 mm or greater, must not exceed stock thickness and to decrease to zero at or before the root of the weld.

1.3.5. Notching – Must not exceed stock thickness and to decrease to zero at or before the root of the weld.

1.3.6. Weld Cracks - None permitted.

1.3.7. Porosity - Individual pinholes separated by at least their own diameter and other scattered porosity will be tolerated. Total length of porosity (sum of diameters) shall not exceed 6 mm (.25 in.) in any 25 mm (1.0 in.) of weld. Maximum pinhole diameter is not to exceed 1.5 mm.

1.3.8. Inclusions - Same as I. GENERAL, H. Weld Quality Requirements, 1.3.7. Porosity

1.3.9. Weld Length allowance is +/- 3.0 mm, or -0/+6 mm for a weld past, unless otherwise specified. Note: Weld past is depicted in section V. INSTRUCTIONS AND NOTES, C. Addendums, Addendum IV. of this document.

1.3.10. Overlap $_W$ (ref. I. GENERAL, F. Welding Terms, 2.5.1) – Not permitted in lengths as specified on the drawing.

1.3.11. Skips - No more than one defect not exceeding 9 mm (.36 in.) long is permitted in any 100 mm (4.0 in.) length of weld. Skips are not allowed in any welds less than 100 mm long. Skips are not permitted closer than 2 5mm (1.0 in.) from the ends of the effective weld.

1.4 Other Weld Quality Characteristics

1.4.1. Weld Leg Size (minimum) - 70% T_1 min. + gap.(Ref: L_1 and L_2 in FIGURES 13 through 16)

1.4.2. Minimum Effective Throat – 60% T_1

1.4.3. Minimum Root Penetration – (ref: Fig 13, 15, and 16) 10% T_1. For parts that have less than 10% T_1 weld root penetration; follow weld repair procedures.

1.4.4. Maximum allowable part gap at ends of each weld length, and at cut sections, is 70% T1, or 175% nominal weld wire diameter, whichever is smaller. Dimension

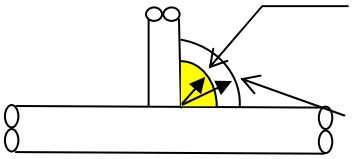
I. GENERAL H, (cont.)

shall not exceed 2.3 mm (0.092 in.) in any case. Weld gaps that exceed 80% of the maximum (56% of T_1 or 140% of nominal weld wire diameter, or 1.84 mm, whichever is smaller) will be reviewed on all parts, and containment actions are to be taken to insure not to exceed the maximums.

1.5 General Weld Defects

1.5.1. Weld Spatter – Surfaces specified on the drawing are to be free of weld spatter.

1.5.2. Surfaces are to be free from weld spatter, burned off wire/fishhooks (wire stub) or any similar sharp protrusion(s) that exceed 5 mm in height anywhere on frame assembly in addition to the design height (Ref: I. GENERAL, B. Design Considerations, 3. Weld Depiction and Callout, 3.3 Weld fill…) unless other requirements are specified on the CAD model, part and/or component detail (Ref: Figure 23).



R = "A" = greater of 5 mm or T_1 per I. GENERAL, B. Design Considerations, 3.3.

R' = "A" + 5 mm – Area of maximum height of spatter, protrusions, build up, overlap–$_L$ etc.

Figure 23

1.6 Workmanship Samples / Visual Aids

1.7 Weld quality will be judged on dimensional and visual appearance considerations as defined by this specification. Workmanship samples (either physical parts or other appropriate pictorial aids), which reflect examples of acceptable quality welds, shall be retained at the manufacturing source.

1.8 Any welding defects are to be repaired within the limitations of IV. REVALIDATION REQUIREMENTS, B. Corrective Action and C. Weld Repair Procedure.

I. WELD CLASSIFICATION / ANALYSIS

1. A number of welds will be classified Prioritized {weld class "**P**"} that are not necessarily part of the complete frame analysis, that are to be sectioned more frequently per II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B. Inspection Frequency. This frequency must be at a rate to allow production certification of each run prior to shipping. The time to complete tests and report is per Tables 2 through 4.

1.1. The Prioritized list of welds will be selected based on information from but is not limited to the following:

1.1.1. Prioritized welds as defined by the D-FMEA (classified as YC), P-FMEA, and / or history.

1.1.2. High stress areas defined by CAE Analysis and/or test, proving ground, or field failures. High stress welds include, but are not restricted to, those welds where stresses exceed 75% of material yield when the total weld length is reduced by the lesser of 16 -20 mm (i.e. 2 x CAE grid size); or a total of 10% of the overall length of the weld, but not to be reduced by less than a total of 12 mm, equally off each end, as determined by CAE analysis. If test validation proves welds at or shorter than the specified shorter lengths are capable of passing appropriate tests in adequate sample sizes (absolute minimum of three), and the weld is not an YC per the D-FMEA, the weld may be classified as "G".

1.1.3. For all subframes and for full frames with steel of 350 MPa or greater: High sensitivity welds are to be classified "P"-welds. Determine high sensitivity with the following method:
Assess the stress level for a weld that is at the nominal design length (baseline stress). Compare the baseline stress to the shortened weld stress (from section I. GENERAL, I. Weld Classification / Analysis, 1.1.2. High stress…) If the "shortened weld" stress is 30% or more greater than the "baseline" stress, this weld will be classified as high sensitivity and will be considered for classification as a "P"-weld.

1.1.4. Welds which cannot be viewed or repaired after assembly are to be considered for "P" classification. There must be a means to insure weld presence.

1.2 Unacceptable unclassified weld(s) received by Ford Assembly Plant(s).

1.2.1. These become class "P" only if concurred through both Ford Engineering and STA. This will be processed through a WERs Notice and detail revision.

1.2.2. Unacceptable unclassified welds that can't be resolved within 24 hours of identification become class "P" unless Ford Engineering and STA grant exception to the supplier in specific incidences. This will be processed through a WERs notice and detail revision.

1.2.3. Note: Once a weld has been moved to the Prioritized list, per item I. GENERAL, I. Weld Classification / Analysis, 1.2.1., or 1.2.2., it can be removed only after an IP-1 level of quality has been re-established, and increased sampling for each weld sample has been maintained a minimum of ten (10) working days. Depending on the severity of the production quality concerns, Ford Motor Company Design and STA representatives can require that a higher sampling frequency be utilized, or longer sample time be required to achieve IP-1 status. The supplier shall submit a SREA to request engineering and STA to consider accepting this weld(s) reverting to a "G" or "GB" class weld. Welds may be individually assessed for status change

I. GENERAL, I,. (cont.)

by plant and/or assembly line.

1.3 Change of "P" class weld frequency.

1.3.1. The frequency of review of a "P" class weld which has been classified "YC" in the DFMEA may be reduced if supported through a review of the D-FMEA, P-FMEA and control plan and after phase III PSW, if IP-1 level of quality has been established, and if after more than 3 months (60 working days) experience at production rate, appropriate data is provided and reviewed through Ford Engineering and STA, and a SREA approved.

1.3.2. A “P” class weld which has not been classified "YC" in the D-FMEA may be changed to a “G” or "Gb" class if supported through a review of the D-FMEA, PFMEA and Control Plan and after phase III PSW, if IP-1 level of quality has been established, and if after more than 3 months (60 working days) experience at production rate, appropriate data is provided and reviewed through Ford Engineering and STA. Said change shall be documented through a processed SREA. The change should be processed through a Notice with the appropriate changes made on the frame or subframe detail (ref I. GENERAL, A. Scope, 1.).

2. The section analysis frequency of all identified welds analyzed as part of the ongoing, General frame analysis {weld class "**G**" or "**G_B**"} (as called out on the frame detail per I. GENERAL, B. Design Considerations, 4. Supplier Section Inspections / Weld Identification) is as reflected in II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS. "G_B" class welds are those that are to be analyzed by the Root Bend or Crush methods per the "G" class frequency. To be classified a "G_B" weld, the weld geometry/type must allow for Root Bend or Crush testing, and stresses across the weld shall be less than or equal to 75% of material yield as calculated via CAE analysis when the total weld length is reduced by the lesser of 16 -20 mm (i.e. 2 x CAE grid size); or a total of 10% of the overall length of the weld, but not to be reduced by less than a total of 12 mm, 6mm equally off each end. The Ford frame design engineer(s) and team will determine and verify that these welds are welds that require more monitoring than Unclassified welds. The time to complete tests and report is per Tables 2 through 4

3. All other welds are 'Unclassified', ("U"). No designation is required on the drawing.

J. INSPECTION PERSONNEL

1. The personnel responsible for compliance with Section I. GENERAL, H. Weld Quality Requirements (Except I. GENERAL, H. Weld Quality Requirements, 1.1.Welded Sub-Assemblies) shall administratively report to the supplier’s Quality Control Department and/or the Weld Process Engineer. While sectioning may be performed by other activities, the results shall be reported to the appropriate quality control activity.

2. Personnel involved in weld inspection shall be certified by the supplier as receiving adequate formal training on the recognition of weld defects, their cause, and effect on the product.

I. GENERAL, J, (cont.)

Training shall consist of a minimum aggregate of 40 hours. Appropriate visual aids of actual welds should be available for this program and in the inspection area.

3. Personnel designated as weld inspectors must have their vision reviewed annually by the supplier for compliance with recognized corrected levels of vision (minimum of 20/30 near and distance). The A.W.S. Qualified Weld Inspector restrictions shall be used as a guideline.

K. INSPECTION AREAS

1. Suppliers are to provide an appropriate environment for weld section inspection inclusive of, but not limited to, appropriate lighting, fixtures, and magnification lenses.

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS

A. VALIDATION TESTS

1. "Production Validation (PV) tests are used to obtain an initial estimate of the process potential to produce parts that conform to engineering requirements, and to identify causal or predictive relationships between significant design and process characteristics (to be used for process control). These tests must be completed satisfactorily using initial parts from production tooling and processes before Part Submission Warrant (PSW) approval and authorization of production parts can be issued. Sampling plans for PV testing must be included in the Control Plan."

2. "In-Process (IP) tests are used to further understand the relationship between significant design and process characteristics and to establish a basis for continuing improvement. Tests must be completed with production parts on an ongoing basis. Sampling plans for both IP testing and evaluation of the significant process characteristics must be included in the Control Plan. When the process is found to be out of control or the test acceptance criteria are not met, the reaction plan approved in the Control Plan shall be invoked."

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, A., (cont.)

Table 1

SUMMARY OF ES TEST AND ACCEPTANCE PARAMETERS

Test Number	*Test Characteristic*	*Test Use*	*Low Tolerance Limit*	*Target Value*	*Upper Tolerance Limit*	*Minimum Conformance to Tolerance*	*Preliminary Control Plan Parameters*
List the Test Procedure specified in Sec.II of this attachment	List the functional or durability characteristics being evaluated by the test	Indicate whether the test is used for PV, IP, or both	Low value of the test characteristics used to judge performance	Optimum Value of Test Character-istics	High Value of the Characteris-tics used to judge performance	See Sec. 8.1 FAP03-150 for guidelines	See Sec. 8.2 of FAP03-150 for Guide-lines Table
A	Dimensional, and Weld Length Inspection - Visual and/or Automated Inspection	DV, PV & IP	Pass – Weld present Minimum length -3 mm (or -0 mm for weld past),Height - -0, Proper appearance, contact between weld and welded part, Meet all weld length requirements, and no unacceptable weld characteristics per section I., H., 1.2 – 1.5 and V., B., 1.1	Nominal length, etc.	Length - +3 (+6 for weld past), Height - +5 mm	Meet	Per II. B. Inspection Frequency
B1	Cross-section and etch	DV, PV & IP	Meet all weld quality requirements Minimum per I., H., 1.3 – 1.5 and V., B., 1.2.	Nominal penetration, etc.	Meet	Meet	Per II. B. Inspection Frequency
Possible Alternative (with written Ford Engineering and STA concurrence)							
B2	Root Bend Alternative test to be performed in lieu of cross-section and etch	PV & IP	Minimum per V., B., 1.3.1., as required	Not break, or break parent (not weld) material	Meet	Meet	Per II. B. Inspection Frequency
B3	Crush Alternative test to be performed in lieu of cross-section and etch	PV & IP	Minimum per V., B., 1.3.2., as required	Not break, or break parent (not weld) material	Meet	Meet	Per II. B. Inspection Frequency

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, (cont.)

B. INSPECTION FREQUENCY

1. Prototype: Prior to and including TT

1.1. All prototype frames are to be 100% visually inspected per III. TEST PROCEDURES, A. Weld Inspection – Dimensional and Visual, 1, 2 and 3.

1.2. Prototype welds are to be inspected per section III. TEST PROCEDURES, B. Weld Analysis Testing, 1.Weld analysis… 1) Weld Section and Etch per the following frequencies:

Table 2: Prototype Testing

Number of Frames Ordered	Minimum Number of Frames to Be Weld Inspected	Specific Instructions
1 to 9	1	Can reduce to 0 with engineering agreement
10 to 50	1	One within first 7
51 to 100	2	One within first 7, plus one between numbers 51 to 100
101 to 150	3	One within first 7, plus one between numbers 51 to 100, plus one between numbers 101 to 150
151 up	4 and up	One within first 7, plus one between numbers 51 to 100, plus one between numbers 101 to 150, plus one additional frame per 100, within the range of 100 1/.

1/ e.g. if order is for 151 to 250 frames, four frames, one of which will be evaluated between numbers 151 and 250; for 251 to 350 frames, five will be inspected, one of which will be evaluated between the 251 and 350 frames built

2. IP-1 (In Production phase 1): after TT to Job #1 (Run at Production Rate) - Table 3.

2.1. After M1 is approved, a frame with all welds shall be high gloss painted, e-coated or black anodized. This frame shall have all welds outlined in white for “G” / "GB" class welds or red for “P” class welds with their lengths. Additionally, the outlined welds will have the agreed to sectioning areas marked in yellow, with a weld numbering scheme relating back to the Frame Print identifying the areas of weld cross sectioning. Interior welds, including in-accessible and “closed out” welds, shall also be marked on the exterior or the frame (E.G. weld plates, nuts, interior reinforcements, etc.).

2.2. The weld sampling shall be one frame, per day, per model, per line or fixture until each section passes all criteria for a minimum of 10 production days, or 5 production days for "G "/"G_B" and Unclassified welds, and concurrence from Ford engineering and STA is received to proceed to IP sampling rates .

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B, (cont.)

2.3. Any alteration, change in process – mechanical, assembly, material, etc., weld wire (inclusive of size of wire, or solid to cored, etc.), changes in weld position or angle, creates a new weld that must be evaluated per IV. REVALIDATION REQUIREMENTS, A. Alteration to Production.

Table 3 : IP-1 Sampling

Test	Test Name	Performed By	Where	Frequency	Test Method	Requirement	Data type	Delivery Time
A	Visual and/or Automated Inspection - Dimensional, and Weld Length Inspection	Operators and / or Quality Technician per III., A.	In-line and off-line dedicated position per III., A., 1 – 3.	Per III., A., 1 – 3.	Per III., A., 1 – 3 and V., B., 1.1. visual	Pass/fail	Attribute	Per III., A., 1 - 3.
B1	Cross-section and etch	Quality Technician	Off-line dedicated position	Per II. B., 2.2.	Per V., B., 1.2., I., H., and III., B.1.1.	Pass/fail	Attribute	Before end of next scheduled shift
Possible Alternative (with written Ford Engineering and STA concurrence)								
B2	Root Bend Alternative test to be performed in lieu of cross-section and etch	Quality Technician	Off-line dedicated position	Per II., B., 2.2., as required per control plan	Per V., B. 1.3.1.	Pass/fail	Attribute	Before end of same shift
B3	Crush Alternative test to be performed in lieu of cross-section and etch	Quality Technician	Off-line dedicated position	Per II., B., 2.2.,as required per control plan	Per V., B. 1.3.2.	Pass/fail	Attribute	Before end of same shift

3. IP (In Production): After IP-1 is approved and at Production Rate – Table 4.

3.1. An agreed to Frame (from IP-1) shall be reviewed. If there are any changes from IP-1, a Frame shall be high gloss painted, e-coated or black anodized. This frame shall have all welds outlined in white for “G“ / "GB" class welds, and red for “P” class welds with their lengths. Additionally, the outlined welds will have the agreed to sectioning areas marked in

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B, (cont.)

yellow, with a weld numbering scheme relating back to the Frame Print identifying the areas of weld cross sectioning Interior welds , including in-accessible and "closed out" welds, must also be marked on the exterior the frame (E.G. weld plates, nuts, interior reinforcements, etc.). If agreed to in advance, only changed welds need to be marked as described

3.2. IP Sampling commences once full production is agreed to (ref II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS 2. IP-1, 2.1)

3.3. Weld sampling for automatic "**P**" classified welds is a minimum of one frame per day, per line. For semi-automatic and manual "**P**" class welds, sampling frequency is one per day, per shift, per line; and frames shall be pulled from alternating shifts such that all shifts are sampled each week, and the operator(s) shall be re-certified annually. For all welding processes, if more than one model is run per day, unique "**P**" class welds will be sampled based on the criteria of one frame per day, per shift, per line.

3.4. "**G**" / "$\mathbf{G_B}$" classified weld sampling is a minimum of one frame, per week, per shift, per line. If more than one model is run per week, unique "**G**" / "$\mathbf{G_B}$" welds will be sampled based on the criteria of one frame per week, per shift, per line.

3.5. Unclassified weld analysis will be a minimum of 1/30,000 frames per line.

3.6. Any alteration in part design, change in material (or source), change in manufacturing process, or change in weld process (e.g. wire inclusive of -size of wire, or solid to cored, etc.) changes in a weld position, or angle, that could affect part function, performance, durability, or appearance creates a new weld that reverts back to the IP-1 weld sampling plan or as agreed to with Ford engineering and STA - until capacity capability is re-established. Costs for any Ford engineering change that results in a new weld, or an existing weld reverting back to PV or IP-1 weld sampling may be included in the quote for the change. Quality actions will not incur any additional costs to Ford.

NOTE: during any weld quality issue(s) any of the above sampling plans can or may be reverted back to. Weld sections shall be taken from the area or areas that have demonstrated a failure or questionable weld (customer issue - plant or dealer). The fall back to a higher weld sampling frequency is the supplier's quality responsibility. It is between Ford Motor Company Engineering, STA, and the Supplier to recognize when this is enforced and for STA and Engineering to determine when this higher weld sampling frequency is returned to the normal sampling plan(s). Depending on the severity of the concerns, a higher sampling frequency may be required to reach IP-1 status.

II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B, (Cont.)

Table 4: IP Sampling

Test	Test Name	Performed By	Where	Frequency	Test Method	Requirement	Data type	Delivery Time
A	Visual and/or Automated Inspection. Dimensional, and Weld Length Inspection	Operators and / or Quality Technician per III., A.	In-line and off-line dedicated position per III., A., 1 – 3.	Per III., A., 1 - 3.	Per III., A., 1 – 3. and V., B., 1.1. visual	Pass/fail	Attribute	Per III., A., 1 – 3.
B1	Cross-section and etch	Quality Technician	Off-line dedicated position	Per II., B., 3.3., 3.4., and 3.5.	Per V., B., 1.2., I., H., and III. B.1.1.	Pass/fail	Attribute	Before end of next scheduled shift
Possible Alternative (with written Ford Engineering and STA concurrence)								
B2	Root Bend Alternative test to be performed in lieu of cross-section and etch	Quality Technician	Off-line dedicated position	Per II., B., 3.4., as required per control plan	Per V., B., 1.3.1.	Pass/fail	Attribute	Before end of same shift
B3	Crush Alternative test to be performed in lieu of cross-section and etch	Quality Technician	Off-line dedicated position	Per II., B., 3.4., as required per control plan	Per V., B., 1.3.2.	Pass/fail	Attribute	Before end of same shift

III. TEST PROCEDURES

A. WELD INSPECTION – DIMENSIONAL AND VISUAL

Welds on all frame assemblies are to have Engineering and STA approved inspection procedures and process controls in place to ensure all welds are present and comply with I. GENERAL, H. Weld Quality Requirements, weld length, qualities and requirements. Visual inspection may be performed by an inspector, repair welder, machine or robot operator. Inspectors shall be qualified under I.GENERAL, J. Inspection Personnel. Use of tooling and automation for compliance is acceptable.

III. TEST PROCEDURES, A, (cont.)

The following weld inspections are required unless otherwise agreed to by both Ford engineering and STA, and noted as an exception on the frame (-5005-) drawing and documented in the supplier control plan:

1. 100% on-line visual inspection to verify all welds are present and appear to comply with I. GENERAL, H. Weld Quality Requirements until other methods are proven effective.

2. Supplier non-destructive formal weld quality visual inspection of 100% of the welds on a minimum of two frames, per shift, per line, per fixture set, for all frame welds. Supplier shall use gages or other measuring tools for compliance to Section I. GENERAL, H. Weld Quality Requirements. Flux removal is necessary for examination of weld surfaces except in the case of wire fed GMAW. This inspection is to be completed within one hour after the frame is removed from the assembly line by a Weld Quality Technician.

3. Supplier inspection for weld lengths of all welds on a minimum on one frame per line per shift. Inspection of manually welded parts is to be completed within one hour after the frame is removed from the assembly line. Inspection of parts welded semi-automatically or automatically is to be completed within four hours after the frame is removed from the assembly line by a Weld Quality Technician.

4. Welds that cannot be viewed or repaired after assembly must have a means to insure weld presence. Engineering should consider classifying these as “P” welds.

B. WELD ANALYSIS TESTING

1. Weld analysis can use any of three tests (Ref Section V.INSTRUCTIONS AND NOTES, B. Summary of Production Validation and In -Process Tests), 1) Weld Sectioning Analysis (Cross-section and Etch), 2) Root Bend Testing, and/or 3) Crush Test.

   Weld Section and Etch is the **primary** test. This specification requires analysis of identified production welds using Weld Section and Etch with minimum frequency as summarized in Tables 1 to 3 above, unless otherwise designated on the frame detail.

   Sectioning not associated with normal requirements may be supplemented by Root Bend or Crush only with prior written approval from Ford Engineering and STA, or if designated on the frame weld detail. Model for weld analysis is to be defined by the program engineer(s) based on commonality and documented on the frame assembly detail. Unclassified welds shall be tested at a minimum frequency per II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B. Inspection Frequency, 3. IP (In Production), 3.5. above, using weld section and etch unless specific prior authorization is provided in writing by Ford Engineering and STA to use other of the testing procedures in this document.

   Note: Root Bend or Crush may be used only with written approval from Ford

Engineering and STA, or if designated on the frame weld detail. Root Bend or Crush Weld Analysis is a supplemental inspection and does not totally replace Weld Section and Etch.

1.1 Weld Section and Etch

1.1.1 Specimen is to be cut from sample, perpendicular to the weld, and long enough to obtain a good view of the weld after preparing the sample.

1.1.2 Specimen to be ground flat to present proper viewing of it.

1.1.3 Microscope inspection to be conducted and proper weld parameters analyzed per recognized software programs.

1.1.4 Etching compounds may be used for better visibility.

1.1.5 Refer to V. INSTRUCTIONS AND NOTES, B. Summary of Production Validation and In-Process Tests, 1.2.

1.2. Root Bend and Crush

1.2.1. Refer to V. INSTRUCTIONS AND NOTES, B. Summary of Production Validation and In-Process Tests, 1.3., below.

2. Completion of weld section analysis (timing): Weld section analysis must be completed prior to the end of the next same scheduled shift; root bend or crush before end of current shift. Sections may be obtained from completed or partial (front, mid or rear stub) frame assemblies as appropriate. Weld sections may be taken from full frames or partial assemblies that have been scrapped from the current day's production for various reasons other than section(s) being checked.

IV. REVALIDATION REQUIREMENTS

The manufacturing source and the design-responsible Product Engineering activity will jointly determine which potential changes to the process; materials or material sources would have significant impact on the product's function, performance, durability or appearance. The supplier will describe these conditions in the Control Plan, along with either (1) the revalidation plan that would be followed in each case, or (2) a provision to submit an amended Control Plan for approval if any of those process changes are planned."

A. ALTERATION TO PRODUCTION

Weld parameters (reference table 4) are locked in once PSW runs are complete, or commencement of building parts to support saleable builds.

IV. REVALIDATION REQUIREMENTS, A, (cont.)

1. After PSW, alteration to the welding process may change the characteristics of the weld (weld size, weld visual aspects, or weld fusion profile). Any changes to an individual weld's parameter(s) requiring re-validation (designated by # in table 4 below) shall cause the Supplier to Section and Etch samples per Sampling Quantity in Table 4 below, using the In Production "P"-Class sampling frequency per II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B. Inspection Frequency, 2. IP (In-Production), 3.3. If following the "P"-Class sampling frequency, the weld fails to achieve the requirements of I. GENERAL, I. Weld Classification / Analysis, 1.2.3., the supplier shall continue with sampling plan frequency associated with "P"-Class welds until the requirements of I. GENERAL, I. Weld Classification / Analysis, 1.2.3., are met.

   Note 1: Possible changes listed in Table 4 shall not be made in conjunction with one another. Only one of the listed changes shall be made before scheduled section and etch occurs. If two or more such changes are made in conjunction with each other, except for Travel Angle plus Work angle, the weld shall be treated as a new weld and immediately re-verified commencing with step II. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS, B. Inspection Frequency, 2. IP-1 (In Production phase 1), 2.2. Any major changes affecting weld processes must be approved and revalidated by the supplier's weld engineer.

   Note 2: The following are examples of changes that require immediate, **mandatory** notification of Ford Engineering and STA:
   - EPA Notification of Water-Shed Compliance, or
   - Changing from Copper Coated Wire to Bare Wire or Heavy Metal Compliance, or
   - Ground Water/Storm or Sewerage Floor Drain Run-Off.

Table 5. Weld Changes / Actions			
Change (Δ)	SREA and Validation Required?	Sampling Quantity (successive samples)	Comments
Refurbishment of tooling.	Yes	3 piece verification and determination #	
Δ Fixture combining operations, or separating operations into new fixtures not positioned in the same location or robot.	Yes	6 piece verification and determination #	
Δ Wire Size	Yes	3 piece verification and determination	Requires change to all parameters
ΔWire Type – frame part of 280 MPa yield or greater.	Yes	3 piece verification and determination #	e.g. ER70-S6 to ER70-S3 or from bare to Cu coated or Cu coated to bare
Δ Wire Type – frame part less than 280 MPa yield	No		e.g. ER70-S6 to ER70-S3 or from bare to Cu coated or Cu

Table 5. Weld Changes / Actions			
Change (Δ)	SREA and Validation Required?	Sampling Quantity (successive samples)	Comments
			coated to bare
Δ Wire Manufacturer – if wire chemistry CANNOT be verified	Yes	3 piece verification and determination #	
Δ Wire Manufacturer – wire chemistry CAN be verified, but unfamiliar supplier to Ford or tier one supplier	Yes	3 piece verification and determination.	For wholesale changes, weld cut and etch, bend and peel and durability proveout may be required per engineering request
Δ Wire Manufacturer – wire chemistry CAN be verified, and supplier known within Ford and tier one supplier	No		
Δ Welding Voltage – Change is +/- 5 % or more before process stability (before IP) is demonstrated.	No	3 piece verification and determination	
Δ Welding Voltage – Change is +/- 5 % or more after process stability is demonstrated. 1/	Yes	3 piece verification and determination	
Δ Welding Voltage – Change less than +/- 5%	No		
Welding Current – Change is +/- 5% or more before process stability is demonstrated	No		
Δ Welding Current – Change is +/- 5% or more after process stability is demonstrated. 1/	Yes	3 piece verification and determination	
Δ Welding Current – Change is less than +/- 5%	No		
Δ Wire Feed Speed – Change is greater than 10% in mm or more. . 1/	Yes	6 piece verification and determination	
Δ Wire Feed Speed is less than 10% in mm	No		
Δ Wire Stick Out – 3.2 mm or more. . 1/	Yes	6 piece verification and determination	
Δ Wire Stick Out – less than 3.2 mm	No		
Δ Weld Arc Length – 3.2 mm or more. . 1/	Yes	6 piece verification and determination	
Δ Weld Arc Length less than 3.2	No		

Table 5. Weld Changes / Actions			
Change (Δ)	SREA and Validation Required?	Sampling Quantity (successive samples)	Comments
mm			
Δ Travel Angle – Change of 10° horizontal or 2° vertical or more. . 1/	Yes	6 piece verification and determination #	See Figure 16
Δ Travel Angle – Change less than 10° horizontal or 2° vertical	No		
Δ Work Angle – +/- 2.5° horizontal or 2.0° vertical or greater. . 1/	Yes	6 piece verification and determination #	See Figure 16
Δ Work Angle – less than +/- 2.5° horizontal or 2.0° vertical	No		
Δ Travel Speed – less than 25% change in . 1/	No		
Δ Travel Speed – 25% or more change in . 1/	Yes	6 piece verification	
Δ Changes from air to water cooling or vice-versa	Yes	6 piece verification	Individual validation
Δ Re-sequence Weld – same part	No		
Δ Re-teach Weld	Yes	6 piece verification and determination #	Individual validation
Δ Material Thickness outside of tolerance specified.	Yes	6 piece verification and determination #	Individual validation
Δ Add Welds	Yes	6 piece verification and determination #	Individual validation
Δ Torch Model	No		Unless welds are re-taught
Δ Mode of Transfer	Yes	6 piece verification and determination #	Requires change to all parameters
Δ Gas Mixture	Yes	6 piece verification and determination	Requires change to all parameters
# identifies where also must demonstrate sustainability per II., B., 3.3.			

IV. REVALIDATION REQUIREMENTS, A (cont.)

. 1/ **For power supplies with adaptive controls, a base schedule shall be the point of reference for changes that are made manually to the weld program. Adaptive changes to the weld schedule made by the Power Supply during the course of a weld are accepted, as long as the base schedule is always the point of adaptive reference**

At anytime from PV to Production, weld quality occurrences may be cause for weld sections to be taken from the area or areas that have demonstrated a failure, instead of location(s) as indicated on the frame print(s). The section and etch location as defined on the frame prints may be changed to improve the scrutiny of sample tests. Change of location requires agreement between Ford STA, PD, and Supplier. The location of the section and etch shall not be moved to

IV. REVALIDATION REQUIREMENTS, A, (cont.)

areas where this technique is not valid (start /stop, overlap-$_L$ (ref I.GENERAL, F. Weld Terms, 2.5.2), radii, etc.).

B. .CORRECTIVE ACTIONS

All non-compliance shall be documented. Documents shall be reviewed at least semi-annually to determine resolution to any repetitive issues. The minimum documentation required is: frame(s) identification, root cause, and repair procedures). Commencing at IP-1, the engineering or line supervisor shall submit these documents to the Quality lead for the assembly line for review and signature, supported by welding data as appropriate.

1. Finish Welding

   Any welds that are missing, below specified length, contain skips, or insufficient throat dimension, may be brought within specification by additional welding. Burn throughs 9 mm (0.38 in.) or less in diameter and undercuts greater than 20% but less than 50% may be weld repaired per IV. REVALIDATION REQUIREMENTS, A. Alteration to Production, C. Weld Repair Procedure, except as noted on the engineering drawings.

2. Off-Line Visual Inspection

   Any visual non-destructive weld joint quality characteristics out of specification must be operator and/or equipment adjusted prior to the next scheduled weld joint quality inspection.

3. Section Inspection

   When any substandard welding is evident in any weld section, the supplier must bring the welding operation into compliance within 24 hours (one working day). Supplier can self certify good stock. (This shall be documented as non-compliance). If the supplier cannot apply corrective action to eliminate the substandard weldment within 24 hours (one working day), the supplier must notify Ford Engineering and Ford STA by phone; and telex or e-mail, within the next 24 hours (one additional working day) for process and QR performance assessment. All suspect stock shall be quarantined. Once stock has been certified and accepted by Ford, the supplier can ship to the production facility. (This shall be documented as non-compliance).

C. WELD REPAIR

Frame assemblies with weldments that do not meet the requirements of I. GENERAL H. Weld Quality Requirements analyzed per III. TEST PROCEDURES must be isolated into a separate storage area if not immediately repairable. The supplier shall furnish to Ford Engineering and Ford STA a listing of the defects and quantity of frames involved for deviation consideration. Ford Engineering will then analyze these discrepant weldments, and determine/approve a weld repair method as acceptable. After approving a repair method an Alert should be issued to authorize a repair procedure for each specific condition and for specific quantities. Welds may not be repaired after finish coating without exact prescribed details of the repair and the process provided and agreed to by Ford PD and STA in writing. If impractical to repair, the alternative is to scrap these frames.

IV. REVALIDATION REQUIREMENTS, C, (cont.)

1. Weld Repair Procedure

1.1 The following procedures are to be followed when weld repairing. Each supplier must demonstrate compliance and obtain Ford Engineering approval for specific defect locations and conditions/facilities utilized for repair. A visual aid display of these procedures in the repair area is required. Weld repairs are allowed anywhere on the frame unless otherwise specified on the assembly detail.

1.2 Weld skips; inadequate leg or fillet size and inadequate weld lengths are repairable by added welding.

1.3 Burn through

1.3.1 Grind off any excess metal from the burn through area, using a disc having a maximum coarseness of 60 grit.

1.3.2 Remove the oxide and bevel the edges of the hole.

1.3.3 A Chill Block may be used if required.

1.3.4 Puddle weld the hole using the same process that was used to make the original weld.

1.3.5 Using the same grinding tool, remove any metal representing excessive weld penetration if accessible.

1.3.6 Build up any localized areas which visual examination indicates an under-filled weld condition.

1.3.7 Grind off any excess metal, if required for clearance purposes.

1.4 Weld Porosity is repairable after grinding out the porosity.

1.5 Undercuts greater than allowed in I. GENERAL, H. Weld Quality Requirements, 1.3.3. and less than 50% T1 are repairable by added welding to meet specification requirements.

1.6 Any burnt off wire, fishhooks, or any similar sharp protrusion that exceed 5 mm in height must be removed.

D. SUPPLIER DATA

1. The physical test specimens or photographs of it are to be retained in an orderly and retrievable manner for 1 month. Adequate written records and photographs to adequately describe qualities of all section inspections are to be kept through the current model year and one (1) year thereafter by the supplier. These specimens and records are to be made available

IV. REVALIDATION REQUIREMENTS, D (cont.)

to Ford Engineering upon request. All weld sections are to be identified as stated in I. GENERAL, B. Design Considerations, 4. Supplier Section Inspections / Weld Identification.

2. Any "P" level weld will have electronically retrievable, tamper-proof documentation for the life of the program plus ten (10) years. This shall consist of a minimum of image and section data, weld #, and Julian Date.

V. INSTRUCTIONS AND NOTES

A. CONTROL PLANS

"Control Plans address all significant design and process characteristics, which include all ES tests and Control Item characteristics. They describe the process potential studies that will be performed for product validation (including PV tests) and the ongoing product and process evaluation for continuing improvement (including IP tests). They include acceptance criteria, sample sizes, frequencies, data analysis methods and reaction plans."

"The Control Plan is developed, and updated as necessary, by the manufacturing source in conjunction with the design responsible Product Engineering activity and other appropriate functions such as STA. The Control Plan defines the management of the upstream production process and part variables (significant process characteristics) that affect the outcome of the ES tests or other significant design characteristics. The Control Plan also identifies the specific ES tests, with their sample sizes and frequencies that will be performed in order to:

- Confirm whether the process is being managed effectively.
- Further identify significant process characteristics.
- Evaluate performance of marginal processes.
- Better anticipate the customer effect of proposed process improvements."

"For any part on which ES tests have been specified, the manufacturing source must present the Control Plan and any revisions to the design responsible Product Design activity for review. This Product Engineering activity has flexibility to honor business relationships with suppliers having proprietary processes."

"Examples of formats for Control Plans are shown in Quality System Requirements, QS-9000."

Periodic test results are to be supplied to the appropriate Design Engineer, STA and affected Plant PMT. This is recommended as a monthly summary of the number of welds inspected, number of welds not completely addressed within 24 hours (ref section IV. REVALIDATION REQUIREMENTS, B. Corrective Actions, 3. Section Inspection), and actions taken to address unacceptable welds.

B. SUMMARY OF PRODUCTION VALIDATION AND IN-PROCESS TESTS

1. Test Procedures and Requirements

1.1. Visual/Dimensional Inspection for Welds.

V. INSTRUCTIONS AND NOTES, B. (cont).

Test Equipment – Scales, calipers, gages, templates, lamps, magnifying lenses, workmanship samples, visual aids, and laser vision and or vision cameras as required.

Visual inspection will be used only as a check for weld location, total weld length, surface finish, visual discrepancies (cracks, burn-through, surface porosity, undercut and gaps), correct number of welds and specified spacing as called out in the weld manual.

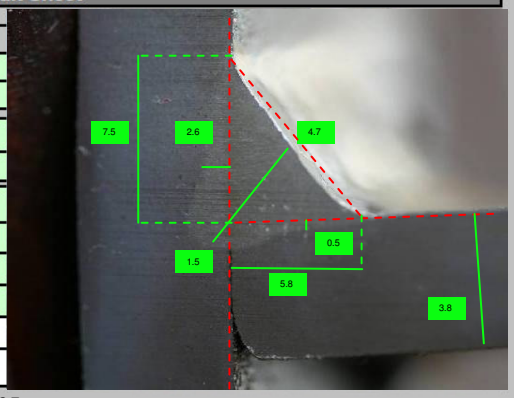
Distortion that occurs as a result of the welding process must be controlled to fall within the tolerances as shown on the engineering drawing.

1.2. Weld Sectioning Analysis (Cross-section and Etch Test)

Macro Result Sheet

WC-TPL-QAD-4080 Issue 4 Date:21/07/09

Tested By:	Date:	10/02/2011
	Welder Name:	
Result:	Welder ID:	
Pass	Test Type:	Weld Test
	Weld Description:	Manual
	First/ Last/ Random	Random
	Part Number:	FORD
	Batch Number:	
Fillet Size	Batch Quantity:	
6	Type of Weld	Fillet Weld
t2 = Thickness of thinnest material (in mm):	3.8	3.8



Customer & Standard	Ford	ESBC34-5005-AA	
Part Number	FORD T6	Part Description	TBM (2) AND TOWBAR
Section Name:	TBM2 PLATE TO LUG BOTTOM (SAMPLE 2)	Drawing No & Issue:	

Weld Settings	FORMULAS:	DEFINITIONS:	Measured:	Minimum Acceptance Requirements:	Outcome:
Wire Speed Ft/Min	Minimum of Thinner Section:	Throat thickness ** - D:	4.70	2.28	Pass
Gas Flow L/Min	Minimum of Thinner Section:	#Leg length - S1:	7.50	2.66	Pass
Amps		#Leg length - S2:	5.80	2.66	Pass
Voltage	Spec.	Maximum Penetration - d1:	2.60	0.38	PASS
	Spec.	Maximum Penetration - d2:	0.50	0.38	PASS
	Spec.	Root Penetration	1.50	0.38	PASS

Figure 24: Sample Weld Analysis

- Welds samples will be tested in location as identified on the detail
- Welds will be measured for proper size, contour and other visual acceptance criteria. Visual inspections are to be enhanced with magnifiers of the standard 10x (e. g. handheld magnifiers).
- Cross-sectioned welds will be polished, etched and evaluated at 5 to 10 x magnifications depending on field of view, with magnification documented with picture or file.

(Ref: Macroscopic Examination of Metals, Principles of Metallographic Laboratory Practice, Geo. Kehl).

V. INSTRUCTIONS AND NOTES, B. (cont).

Minimal acceptable conditions for Cross-section and Etch Test:

- Welds must show positive evidence of fusion from the root to the toes and must meet the minimum size and throat as defined in:
  - the Engineering Assembly Detail (governing document), or 2nd
  - this specification section I, GENERAL, H. Weld Quality Requirements, or 3rd
  - 5.3, AWS D8.8-0 (third). The first listed governs over the following one(s).

- There shall be no evidence of weld metal overlap-w (ref. I. GENERAL, F. Weld Terms, 2.5.1) and/or incomplete root penetration as illustrated in Figure 22 (above).

Note: The depth to which the base metal has melted during welding is the "Depth of fusion". Adequate fusion is characterized by torn base metal. Lack of fusion is characterized by a straight "line" which is the unfused edge or surface of base metal that did not melt or become a part of the admixture.

1.3. The following mechanical test methods may used to supplement cross section and etch testing:

1.3.1. Root Bend Testing

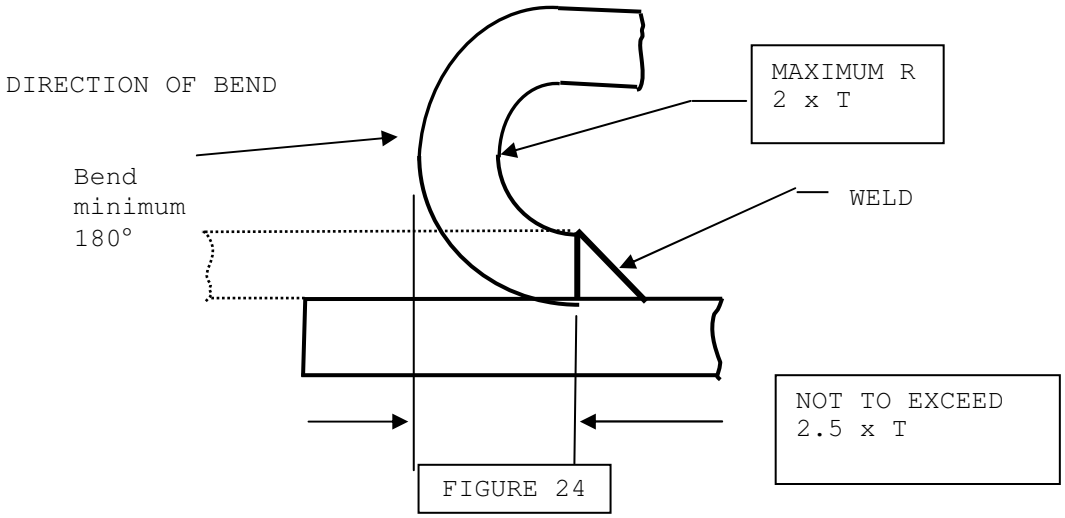


FIGURE 24

Plasma arc cutting or other mechanical means may be used to cut sections small enough to root bend. Root bend test will be performed in conjunction with the Cross-section and Etch Test to validate the evidence of fusion for the entire weld using the same sample where feasible. For weld one inch or smaller Cross-section and Etch test validation will be satisfactory. Root Bend Testing requires bending the base metal adjacent to the weld in the direction of the face of the Weld as shown in Figure 24.

Minimum acceptable condition for Root Bend Test:
Base metal must be folded a minimum of (180°.) without the weld breaking (the root of the weld must be visible), or
Base metal tears out with the weld, or

V. INSTRUCTIONS AND NOTES, B. (cont).

Weld fractures though the throat (in metal thickness over 3 mm) - root fusion must be evident and visible.

1.3.2. Crush Test

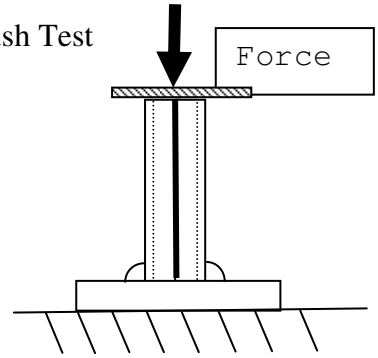


Figure 20

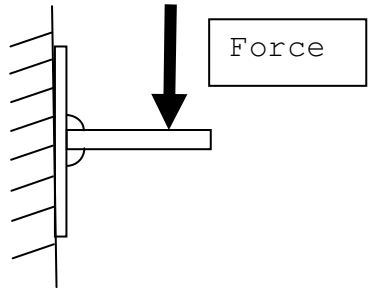


Figure 21

Mechanical testing such as crush test may be used to supplement root bend and chisel testing. Process/procedure and method of testing will be documented, and the method, frequency, and location will be documented in the Weld Control Plan.

Minimal acceptable conditions for Crush Test:

Evidence of fusion from the root to the toes
No evidence of metal overlap-$_W$ (ref: I. GENERAL, F. Weld Terms, 2.5.1) and/or incomplete root fusion.
Adequate fusion is characterized by torn base metal, and/or fracture face with ductile features.

C. ADDENDUMS

Addendum I - Considerations for Proper Stamping and Welding of New Materials or Proto-Type Materials, Stampings, and Mechanical / Draw Pierce Operations

Note: The following requirements shall be evaluated and complied with as appropriate prior to approval for new components, or any change in Process or materials.

Introduction: This pertains to Materials that are classified as HSLA, UHSS, AHHS, Micro Alloy, B (Boron), Hot Form, DP (Dual Phase), SF (Stretch Flange) TRIP, etc. (all steel alloys with tensile strengths at or above 420 MPa (60.9 Ksi) or those materials that use high or low pressure bending (Hydroform, tube bending, or expanding type devices or mandrels)). This addendum also pertains to rolling mills where special steel formulations could produce (but not limited to); folds, cold laps, banded microstructures, ferrite counts, magnetism, and other metallurgical issues that may be detrimental to down stream processing. This requirement is also inclusive for materials using process annealing, during stamping, bending, or forming operations (inclusive of tube rolling mills).
Common Misconceptions**:**
40% thinning is not the same as 40% elongation. 40% thinning takes away 40% of the load bearing capability (neglecting the effects of work hardening).

V. INSTRUCTIONS AND NOTES C. (cont).

Note; The following are engineering tools which are useful in validating forming or welding processes. These tools may be used singularly or in combination with each other, dependent on component complexity and/or material reduction (as noted by the procedures that follow).

1) FLD (Forming Limit Diagram); shall be conducted and submitted to Ford engineering for approval, for new processes or any change in process once approval to tool has been granted by Ford. (Source – frame assembly or final component supplier)

2) CGA (Circle Grid Analysis); shall be conducted and submitted to Ford engineering for approval for new processes or any change in process once approval to tool has been granted by Ford. (Source – steel mill or stamping house)

3) TLD (Thinning Limit Diagram); shall be received from / reviewed by the Steel Supplier and submitted to Ford engineering for approval, for new processes or any change in process once approval to tool has been granted by Ford.

Steel Suppliers should support all of the items listed above at the die development stage at the die site.

4) New Material Weld Analysis (NOTE: The cold test is Ford responsibility); For materials classified as described above-in V. INSTRUCTIONS AND NOTES, C. ADDENDUMS, Addendum I, Introduction, undefined for welding or subjected to welding that is not customary for the known material, weld tests must be conducted that comply to FLTM (Ford Laboratory Test Method) **BA 113-08** "Spot Weld Test Criteria for Bare and Coated (Zn & Zn/Fe) Low Carbon and Medium Strength Steel Sheet" or applicable industry standard(s), e.g. **AWS D-8.9 M: 2002** (basis for BA-113-08).

The general Ford vehicle minimum temperature test requirement is - 40° C (-40° F), but welding components of materials not common to the selected welding process may result in weldments that may be subjected potential environmental temperatures of -54° C (-65° F) or lower. It is strongly recommended that these component weldments be subjected to metallurgical evaluation and weld analysis (Charpy Impact, cut - mount – polish – etch - microstructure analysis, chisel, peel, crush, or similar evaluation(s)), after a cold soak to a minimum of - 54 °C (- 65° F) (min of 3 samples). Actual components, or surrogate parts of the same mass, material weld stack up and thicknesses, may be used for these tests:

Mechanical Test Verification: If the materials fall into the classes of materials mentioned in V. INSTRUCTIONS AND NOTES, C. Addendums, Addendum I, Introduction, verification should consist, at a minimum, of mechanically testing samples at room temperature and samples subjected to cold soak for any mechanical property change(s) per the following:

Ambient Temperature (20° C (68° F)) – Mechanically test a minimum sample of 3 at room temperature. Evaluate the joint through the use of known tests: Charpy Impact Test, chisel test, root bend, metallurgical, or crush test, using coupons or surrogate parts of adequate size and mass. Perform fastener testing, as applicable.

V. INSTRUCTIONS AND NOTES C. (cont).

Cold Soak Test: Mechanically test a minimum sample of 3 at -54 C (-65 F) (a known cold soak source is ATNPC Livonia). Parts should be tested as quickly as possible, not to exceed 10 minutes, after removal from cold soak. Evaluate the joint through the use of at least the same known tests used for ambient temperature evaluation: Charpy Impact Test, chisel test, root bend, metallurgical or crush test, using coupons or surrogate parts of adequate size and mass. Perform fastener testing, as applicable.

Test Results: If Charpy Impact and/or other tests indicate significant material property decrease(s), alternative actions are required, potentially consisting of post stamping, forming, or weld process changes.

Addendum II - Tools for Verification of Thinning and Splits (Ford operating procedures take precedence over the following)**:**

1) Vernier Calipers, Micrometers, Blade Micrometers, etc., - these instruments shall be capable of accessing the specific area in question and shall be held perpendicular or normal to the surface to be inspected. All instruments and shop tools shall have last in house calibration date and sticker with traceability to NIST.

2) Ultrasonic Testing (refer to Ford Policy Letter L-4): Probes shall have a calibrated standard with last in house calibration, including date and traceability, to NIST. The correct surfactant/couplant, as directed by the ultrasonic tester and probe manufacturer(s), shall be stated and used in all calibration and inspection procedures. All probes and standards in conjunction with the electronic box shall have last in house calibration date and sticker with traceability to NIST.

3) NDT / NDE Processes (non-destructive testing / non - destructive evaluation)**;**
Direct Current (D.C.) - surface fine / hair line to sub-surface 0.63 mm (1/4 ").
Alternating Current (AC) - surface fine / hair line to just under sub-surface 0.31 mm (1/8 ").

4) Fluorescent Penetrant Inspection (FPI), - surface only, surface fine / hair line.

5) Stress Analysis, - X-Ray diffraction

V. INSTRUCTIONS AND NOTES C. (cont).

Addendum III – Trouble Shooting Guide

GMAW (MIG/MAG) Welding

Typical Weld application quality defects to prevent

		Weld Defect/Issue												
	Possible Causes	Porosity	Lack of penetration	Lack of fusion	Undercutting, Burn Back/Notching	Cracking (hot or cold)	Unstable arc	Poor weld starts/wire-stubbing	Excessive spatter	Burn-thru	Convex bead	Concave bead	Offset	Comments
Weld schedule	Welding current too high				X					X		X		
	Welding voltage and/or current too low		X	X							X			
	Weld voltage too high				X							X		
	Welding voltage too low							X	X		X			
	Inductance or slope too high							X						
	Inductance or slope too low								X		X			
	Wrong polarity			X							X			Should be DCRP (direct current electrode positive)
	Torch angle incorrect		X	X									X	
	Torch oscillation too wide/too narrow		X	X										Improper use of weld pattern (i.e., weave)
	Arc length		X		X		X	X		X		X		
	Weld travel speed too high		X	X	X									
	Weld travel speed too low									X		X		
	Insufficient dwell at edge of weld bead				X							X		
	Weld bead too small					X								
Electrode/Filler M	Electrode weld-puddle rolling in front of the arc		X								X			
	Excessive electrode extension		X	X				X			X			
	Incorrect weld wire (incl. type and diameter)	X	X	X		X					X			Need higher Mn and Si content to eliminate porosity
	Wire Stick-out				X		X	X		X		X		
	Inconsistent wire feed system						X							
Shielding gas	Incorrect %He in shielding gas								X			X		Decrease % He
	Incorrect shielding gas		X						X	X		X		Use Ar-Co2 or Ar-O2 vs. CO2
	Shielding gas issues	X												Wind, clogged/small nozzle, damaged hose, excessive flow, etc.
	Insufficient shielding gas	X					X							
Other (Design, Maint., Quality)	Welding over convex bead			X										
	Welding over slag from covered electrode	X		X				X						
	Oil, rust, scale, etc. on plate	X		X				X						
	Excessive gap/poor joint fit-up		X	X						X		X		
	Decrease width of root opening									X				
	Weld joint too narrow		X								X			
	Poor quality of material being welded		X	X		X					X			
	Edge dimensional issues		X		X									
	Poor joint design		X	X		X	X				X			

V. INSTRUCTIONS AND NOTES C (cont).

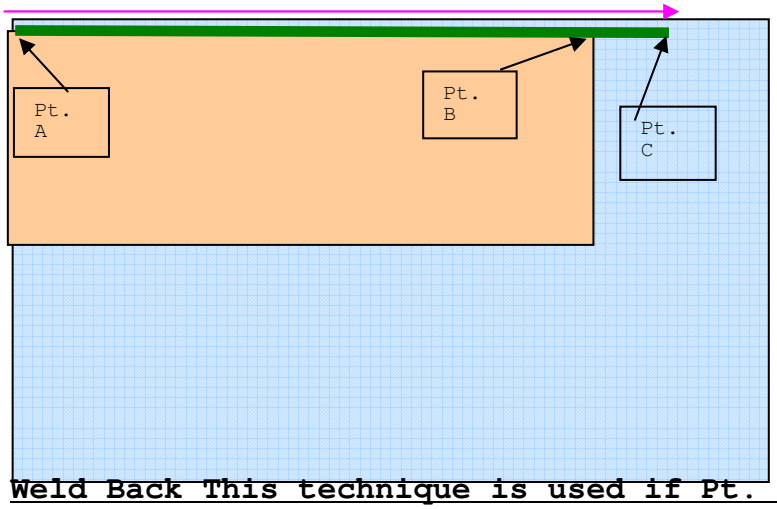
Addendum IV – Weld Past / Weld By / Weld Back

Stamped and welded steel components have a sign-off criterion for welding utilizing FEA. FEA and the DV testing must be performed at worst case conditions to ensure design robustness.

EXPLANATION:

CAE, and design and release, need to work together on FEA analysis to ensure stamped and welded steel components are designed to an optimized welding process. High stress zones need to be accurately identified for parts in the lower end of the tolerance range and weld termination points should be designed to start and end outside of those zones. Also, DV testing needs to performed with worst case production conditions to ensure robustness of design within all levels of production variation.

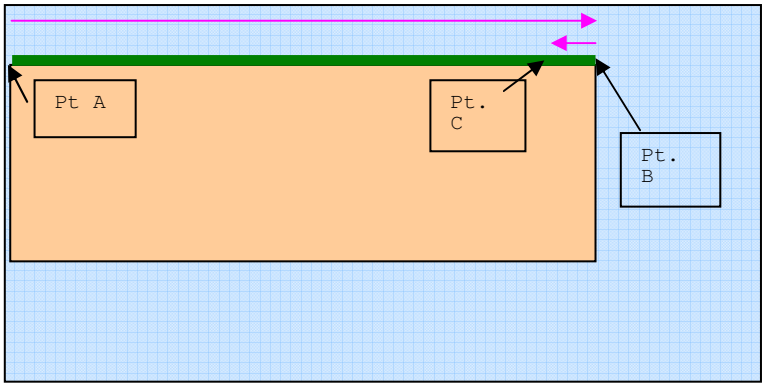
ANALYSIS: Weld By



Welding the Blue part to the Orange part.

The bold green line is the required weld for Weld By (Goes from Pt. A to Pt. C).
The pink arrows indicate the direction of the welds.
1. Start welding at Pt. A (typically 6 mm before the theoretical start of weld)
2. Weld to Pt. B, and
3. Continue to Pt. C
4. Terminate the weld at Pt. C (outside the Pt. B high stress region identified in FEA).

Weld Back This technique is used if Pt. B is a high stress location, but a weld by is not possible.



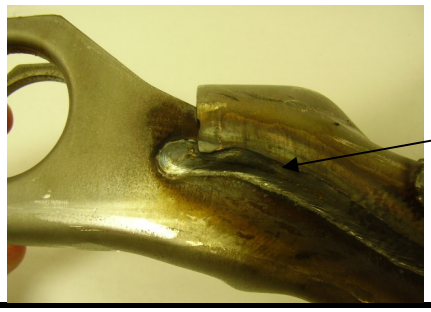
Welding the Blue part to the Orange part.

The bold green line is the required weld (Goes from Pt. B to Pt. C).
The pink arrows indicate the direction of the welds.
1. Start welding at Pt. A (typically 6 mm before the theoretical start of weld)
2. Weld to Pt. B, and
3. Weld back over the weld and continue to Pt. C
4. Terminate the weld at Pt. C (outside the Pt. B high stress region identified in FEA).

DISCUSSION FOR USE:

Guidelines are established for welding sign off criteria that design and release engineers need to uphold

with the assistance of CAE (Ref ESBC34-5005-AA **I. GENERAL I. Weld Classification / Analysis. 1.1.2 and 1.1.3**). Utilization of the weld by design philosophy described in Frame-Subframe SDS **FR-0108** should be considered for all stamped and welded parts with high stress areas around weld termination points.



The weld on both sides of the part extended to 10mm run-off zone. The assembly print was updated to reflect the run-off requirement.

VI. COMPILATION OF REFERENCE DOCUMENTS

- American Welding Society's (AWS) publication AWS A3.0—2001 "Welding Terms and Definitions".
- AWS D8.8-2007 - Specification for Automotive and Light Truck Components Weld Quality - Steel Arc Welding (SAE JSH-1196)
- AWS D1.3-98 - Structural Welding Code - Sheet Steel
- AWS D9.1M/D 9.1-2000 - Specification for Welding of Sheet Metal
- VOPSSN-008 - Weld Quality Program-Spot Weld Classification & Vehicle Operations Manufacturing Engineering Quality Policy Letter L-4 (use of Ultrasonic Testing for RSW attachments)
- VOPSSN-018 – Assembly Tool Certification and Weld Specification.
- ISO 2553:1992(E).
- Ford W Series fastener standards (WE500, WE501, and WE960).

ESBC34-5005-AA_v2_ 3May2011.doc

(End of Document)