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Perspectives on Writing a Welding Design Guide

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Guide to this Presentation

- Some initial remarks
- What does a Design Guide accomplish?
- How does it do this?
- What is desirable content?
- What is undesirable content?
- Sources
- Examples
- Some final philosophizing.....

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Who Should Write a Welding Design Guide?

- Someone with lots of experience working with designers, developers, welders and QA folks
- At least a century of experience

- Which means: No one person alone can do it!
  - Need design perspective
  - Need development perspective
  - Need production perspective
  - Need QA perspective

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What Does a WDG Hope to Achieve?

- It hopes to be a "living document" that provides technology transfer from "experienced" weld engineers and designers to inexperienced weld engineers and designers, smoothing the design-development-production path's many bumps.

- Worst case, it's an archival storage of corporate knowledge, helping understand why "sure things" went wrong.

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What Should Be in a WDG?

- Guidance on:
  - Weld geometry selection (service environment-driven)
  - Process selection (trade-offs: equipment cost vs productivity vs piece part tolerances, plating, cleanliness requirements, heat input vs distortion, filler metal requirements, reworkability)
  - Materials selection (compatibilities & incompatibilities, expected FZ & HAZ properties, distortion tendencies)
  - Specification requirements
  - Process verification procedures (statistics for both development and production QA)
  - Inspection procedures (both destructive & non-destructive, enhanced inspectability geometric features)
- References (literature, examples, memos, reports)
- Resources (people)

What Should NOT Be in a WDG

- Too much detail (give a designer a 300+ page tome, and it won't get looked at)
- Opinion rather than fact (if present, it should be identified as such)
- Actual weld schedules (however, references should be provided)
- Classified information

Example of a WDG with a PA (Honeywell FM&T) Perspective

Design for Manufacturing Guide 1477167 Laser Welding (J. Samayoa, 9/1/2010)

Table of Contents

Lap Joint (Seam or Spot)

- Pros:
  - Side fit-up concerns are non existent with "Lap Joints" because they do not abut to a mated part. Further they do not rely on machining tolerances for side fitup conditions. Fabrication of assembly is cheaper. The weld nugget, distance measured across the fused interface, defines the weld penetration.
  - This joint prevents shine-through.

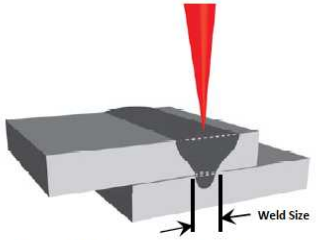
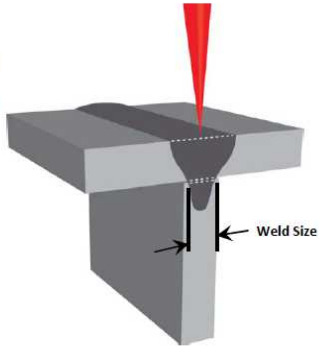


Figure 10 Lap Joint on Base

- Cons:
  - Alignment of the seam weld relies on the accuracy of the positioning system. The fused interface area can not typically be visually confirmed post welding.
  - 100% inspection of joint penetration is typically not possible.
  - This joint is less suited for applications requiring strength and hermeticity.
  - Intimate contact is required.



- Applications: Satellite Decks

Figure 11 Lap Joint on Edge

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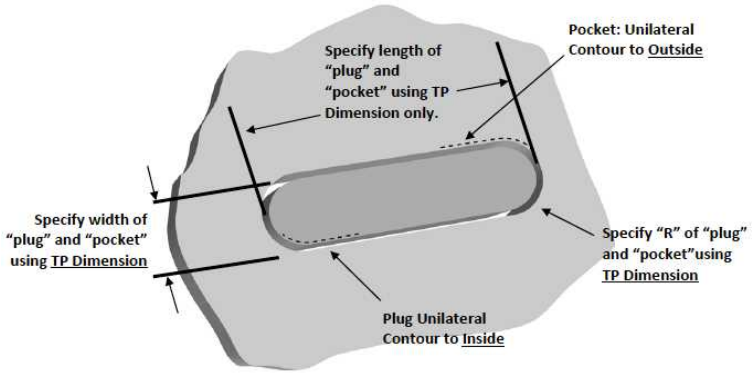
Example 2 PA WDG



Part Contouring

Part Contour, Other Dimensioning Criteria
Contour dimensioning should be used for non-circular shapes, i.e. do not use "dual dimensioning" of length, width and radii, i.e., do not use both a contour limit and bilateral tolerancing of features.

The plug and the pocket should be designed to fit line-to-line and to incorporate unilateral TP and contour dimensioning as follows:

The "plug" should specify a unilateral contour to the inside (the plug can only get smaller).

The "pocket" should specify a unilateral contour to the outside (the pocket can only get larger).

Diametrical dimension should be used for circular shapes

The circular welded "plug" and mating "pocket" should be dimensioned line-to-line (same diameters) and incorporate diametrical dimensioning as follows:

Up to 1-inch diameter, plug should specify +0.000 / -0.001-inch diameter (the plug can only get smaller).

Up to 1-inch diameter, Pocket should specify +0.000 / +0.001-inch diameter (the pocket can only get larger).

For larger sizes consult with welding engineer.

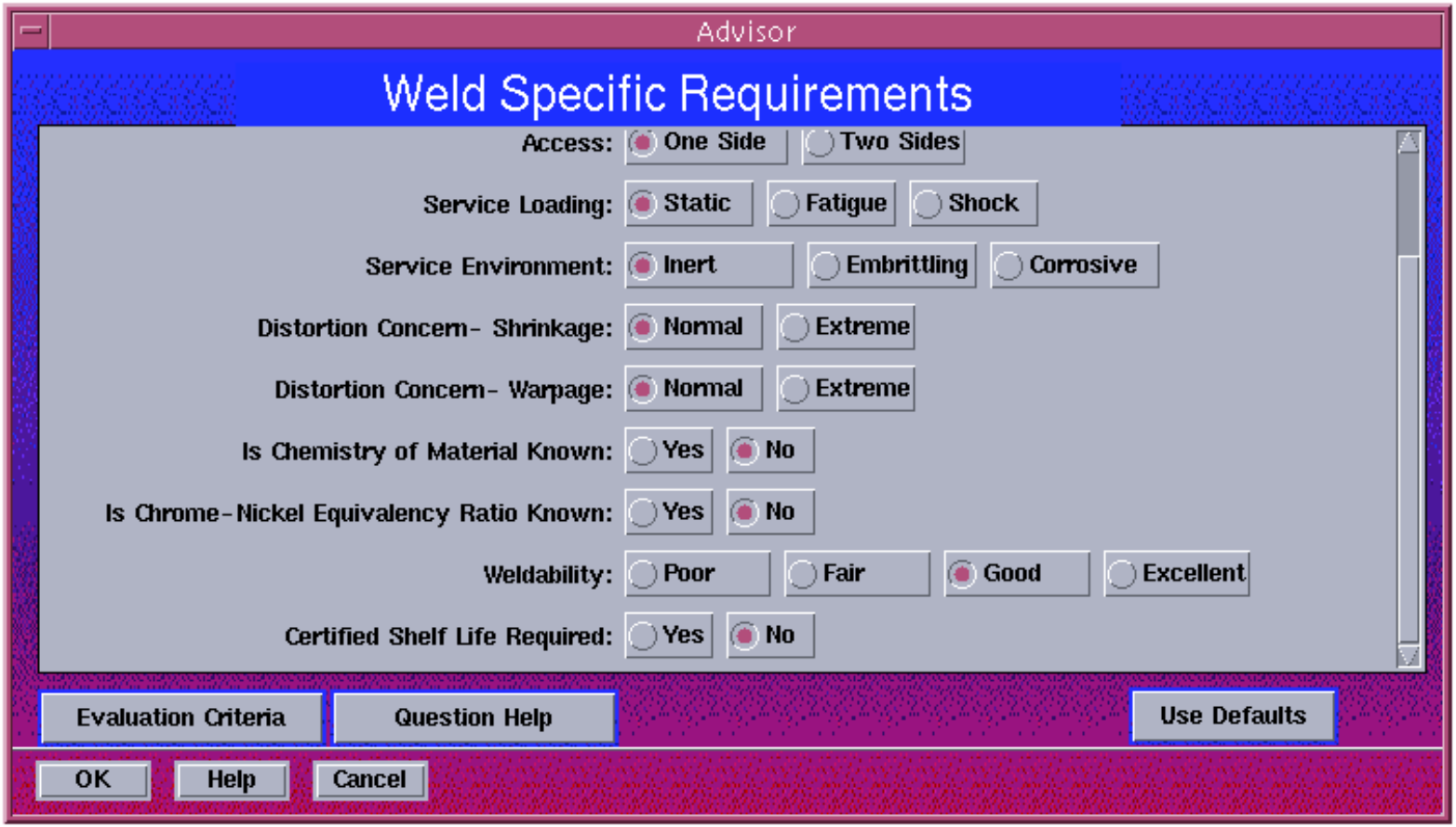
Small pins to 1/16-inch (ref. only) may be pressed-fit.

When contouring, the corner radii will determine the maximum welding speed. For continuous welds the minima radii (ref. only) should be 0.150-inch to allow for good process joint tracking at fast welding speeds. Note: For CW welds, typical welding speeds are 60 – 120 inches-per-minute (IPM).

The typically slower pulsing frequency of pulsed YAGs dictates slow welding speeds and provides enhanced joint tracking of sharp corner radii. Pulsed YAG welding speeds are typically 1 – 5 IPM, as reference only. Faster speeds are possible at lower penetrations.

Example of a WDG with a DA Perspective

- SMARTWELD Design Guide (Ken Hicken SNLL, me, SNLA, ca.1993)



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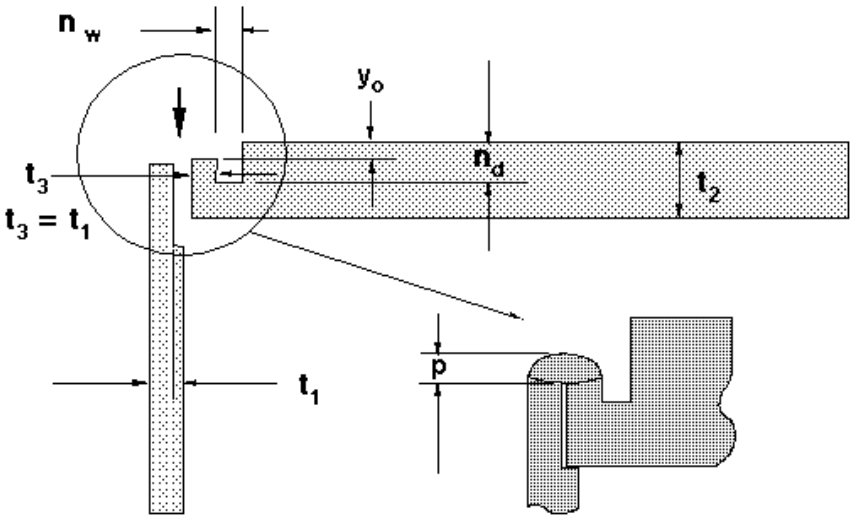
Example 2 DA WDG

	What is the primary function of the joint?		
Joint location?	Structural	Environmental Barrier (Hermeticity)	Attachment
At an edge or corner	Corner, (not recommended)	Corner or Lap	Spot, Lap, Butt Fillet
In a wall away from corners or edges	Complete Penetration Groove Butt Weld	Butt or lap	Spot, Lap, Butt or Fillet
Equatorial or at the end of linear member	Complete Penetration Groove Butt Weld	Butt or Lap	Spot, Lap, Butt or Fillet
Associated with tubulation (tubing with <=6 mm OD)	Complete Penetration Groove Butt Weld	Pinch	Fillet or Plug

DA DG III

Corner Weld Geometry with Alignment Feature and Relief Notch

Located corner joint with relief notch. Shown with notch in the horizontal part, though upon occasion the relief notch may be in the vertical part when it is relatively thicker. Sometimes the locating feature is left off (such as in thermal batteries where the stack pre-load may cause variations in vertical height of the header relative to the can).



Processes Applicable: **GTA, LW, EBW**

Weld Sizing:

y_0 = vertical tolerance of contents + 0.5 x t_1

$n_d \geq 1.5 \times t_1 + y_0$ Notch depth depends upon need for rework

$t_2 - n_d \geq t_1$ $n_w \geq n_d - y_0$ desirable, bottom corners of notch may be rounded

$n_w \geq t_1$ $t_1 \geq p \geq 0.5 \times t_1$

Part Machining Tolerances: **For LW will be tight to moderate, for GTA will be moderate. Tolerances must tighten as part size gets smaller. But first see Figure 3f to determine if tolerancing is an issue.**

Specifications: **NA**

Useful Features: **Used where a) material has weldability problem, b) a thermal or stress sensitive feature is located near joint or c) one part is much thicker than the other.**

The corner joint with header notch (with or without alignment feature) is amenable to rework; an initial partial penetration weld may be machined off, leaving both lid and housing reweldable.

Limitations/Requirements: **Especially for laser welding, the machined edges must not be beveled or broken, though they must be deburred (except for the groove bottom corners) Occasionally, to ensure tight fit up, one of the parts will be swaged to cause a press fit. This is more common with formed parts than with machined parts.**

Particularly when used with GTA, heat sinking will be required if thermally-sensitive regions are nearby. It is essential to a reproducible weld that the heat sink be reproducibly located with respect to the weld joint.

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Other DG's at SNL

- DG10139 C Design Guide Welding, General, 74 pages of design guide type information, appears to be a compendium from multiple sources, no author given.
- SSXXXXXX specs: more specific, often state that they are not intended to be "general" (but everyone copies them anyway).
- Packaging Design Guide (includes joining, but treats a wide variety of other technologies, as well).
- Special weldable material specs (e.g., restricted Cr_{eq}/Ni_{eq} Stainless, can be either X,XXX,XXX or SSXXXXXX).

DG Sources

- AWS (Recommended Practices, Handbooks, D1.X Code)
- ASM Int'l. (Handbooks, Sourcebooks),
- ASME B&PV Code (details often buried in Code Cases),
- AASHTO, ACI, ABS, API (bridges, buildings, ships, pipelines, seem to be migrating to AWS),
- NASA, various Military documents (aerospace, usually more exotic materials),
- Accident Investigations (Earthquakes, Fallen bridges, other calamities/disasters)

- Manufacturer's literature such as: Lincoln Electric's Procedure Handbook of Arc Welding (Omar Blodgett),

- Welding Research Facilities (EWI, TWI),
- Weld design software houses.

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What's Good... ?

- FM&T LWDFMG provides specific guidance on manufacturing requirements for a class of welds appropriate to mechanisms for laser welding only (focused, specific information).

- SWDG offers a broader perspective as to why certain joints/processes are desirable in a given application: it provides design info, process guidance, materials info, spec info, inspection info.

What's Not So Good.....?

- **FM&T LWDFMG provides specific guidance on manufacturing requirements for a class of welds appropriate to mechanisms, for laser welding process only (focused, specific, information)**

- **SWDG tries to be too general; provides design info, process guidance, materials info, spec info, inspection info, and is incomplete.**

The Ideal WDG is....

- Electronic rather than paper, and uses hyper-text links,
- Platform-transparent (SWDG "disappeared" when its original server was retired),
- Owned by an organization that keeps it updated for the long term,
- Limited in goals (a first resource, not intended to supplant actual experts),
- A handy resource for corporate knowledge.

Final Philosophizing

- **Writing a DG is a humbling challenge:**
  - **It makes you categorize your knowledge (and exposes your ignorance!)**
  - **It makes you sensitive to your audience's needs**
  - **It teaches you quickly how much you need to rely upon your colleagues**
  - **It makes you realize how badly you haven't kept up with the literature**
  - **You learn quickly that it's a Sisyphus-ian endeavor**
  - **It gives you a warm feeling that despite all the above, you've performed a useful task!**
- **Given the huge generational turnover presently being experienced, this issue is immediate and important.**

Acknowledgments

- Ken Hicken, Phil Fuerschbach, Charlie Robino, Ed Thomas, Lou Malizia, Jim Jellison, Danny MacCallum and many others at SNL,
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- Numerous others, who've helped drag me out of the "ivory tower" onto the shop floor over the years!

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