The importance of bevel geometry

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Introduction.
The purpose of this presentation is to discuss the importance of pipe bevel geometry in terms of:

- Quality
- Integrity
- Schedule
- Costs
Why is bevel geometry important?

Research indicates that bevel geometry significantly influences the weld quality – specifically when using automated welding systems.

Laser-based end measurement systems are becoming more widely used to map the shape of pipe geometry to assist with fit-up (i.e. ± 50 µm tolerance).

By comparison, traditional bevel geometry measurements are somewhat primitive.
Is bevel geometry important?

“Bevel geometry is one of the most important parameters in mechanised pipe welding.”

Joel Troyer, Technip

“One of the most crucial steps in pipeline welding is to ensure bevel geometry and fit-up are correct.”

Peter Barron, Pipeline Technique (PTL)

“Ensuring bevel geometry and fit-up is correct is one of the most critical steps in pipeline welding.”

Simon Pike, McDermott
High tolerance bevel geometry can help to...
And can also help...

**IMPROVE...**

- Welds per hour: 9 to 10
- Welds per shift: 70 to 77
- Health and Safety
  Pipeline Integrity
  Overall Quality

**INCREMENTAL IMPROVEMENTS**
Weld Accepting

1. Rejected weld despite good bevel and pipe end shape
   • Welding inputs:
     • Welding current
     • Travel speed, etc.

2. Welding issues as a result of bevel being out of spec.
   • Bevelling process:
     • Cutting tool needs replacing, etc.

3. Welding issues as a result of poor end geometry:
   • Internal / external misalignment (HiLo)
     • OOR, Localised peaking / flat spots
     • Wall thickness variation

No Action Required!
No Action Required!

Weld Accepted

Pipe End within Specification

1. Rejected weld despite good bevel and pipe end shape
   •  Welding inputs:
     •  Welding current
     •  Travel speed, etc.

2. Welding issues as a result of bevel being out of spec.
   •  Bevelling process:
     •  Cutting tool needs replacing, etc.

3. Welding issues as a result of poor end geometry:
   •  Internal / external misalignment (HiLo)
     •  OOR, Localised peaking / flat spots
     •  Wall thickness variation

4. Unknown features of the pipe end or bevel geometry
   •  This is largely dependent on the measurement procedure adopted and standards adhered to.
Example of a ‘Scenario 4’.

- Pipe end may appear to be within specification but the bevelling process may produce poor bevels due to the flaring
- In this case, the root face was too thin – but only on the pipes with high flaring

4. Unknown features of the pipe end or bevel geometry
- This is largely dependent on the measurement procedure adopted and standards adhered to.
Bevel types.

Plain bevel.

J-prep bevel.

J-prep with back bevel.

Compound bevel.

Compound J-prep with back bevel.

Key.

- WT: wall thickness
- R: bevel radius
- D: internal taper angle
- F: root face + int. taper height
- A: bevel angle
- W: half opening
- L: land
- H: internal taper length
- T: root face
- B: bevel angle
- E: inflection
J-Prep Bevel for **high-production** with **automatic welding**

High heat on small area

Small amount of material removed during machining – low volume of weld material needed
J-Prep Bevel for **high-production** with **automatic welding**

- Burn through
  - 12 o’clock
  - Too thin

- High heat on small area
  - High sensitivity to land thickness and root gap

- Lack of penetration
  - 6 o’clock
  - Too thick
J-Prep Bevel for high-production with automatic welding

- Burn through
  - High heat on small area
  - High sensitivity to land thickness and root gap

- Lack of fusion
  - Sensitivity to half opening and bevel angle

- Lack of penetration
  - Too thick

- Under fill
  - Too large

- Too thin

- Too large
J-Prep Bevel for high-production with automatic welding

- **Burn through**
  - Too thin

- **Lack of fusion**
  - Too large

- **Lack of penetration**
  - Too thick

- **Under fill**
  - Too large

**Bevel geometry has nominal values and tolerances as per the WPS – i.e. Land thickness = 1.5 mm +/- 0.3 mm**

**Lessons Learnt / Reject Classification**
- High heat on small area
- High sensitivity to land thickness and root gap
- Sensitivity to half opening and bevel angle

- 5%-10% reject rate on welds for the project

- Bevels at the limit of tolerance with ‘on-the-limit’ pipe end shape
Examples.

**Oversized**: Half opening, bevel angle, land

Increased volume of weld material needed to fill weld opening

**Undersized**: root face thickness

- Excessive penetration
- Burn-through
- Under-fill

**Oversized**: root face thickness

- Lack of penetration
A weld cut-out after inspection fails weld leading to:

- Project downtime
- Additional cost
Secondary impact.

Potential to improve fatigue strength in critical region (i.e. TDZ)
Bevel measurement.

- In this case the half opening of a J-prep bevel is being measured using Vernier calipers, a ruler and a spirit level

- Accurate?
- Repeatable?
- Recordable?
Bevel measurement challenges.

- Counterbored pipe with non-axial counterboring
- Defining your datum is extremely important
- Bevel dimensions
- End squareness
- End flaring
- ID, OD, ovality, WT
Lessons learned.

- **Bevel Geometry**
  Land, root thickness, half opening...

- **Pipe End Geometry**
  OOR, peaking/flat spots, wall thickness

- **Welding Inputs**
  Welding current, travel speed, wire feeding speed

- **Operational**
  Welding team, time of day

1. In reality the relationships would involve many parameters and not be easily visualised – but this does not stop multiclass classification from working.
End goal.

- Full knowledge of the pipeline properties
- All data in one location allowing easy access and correlation

✓ Pipe number, coating properties, heat number
✓ Inner diameter, wall thickness, outer diameter, ovality
✓ Bevel dimensions
✓ Pipe length
✓ End squareness and straightness (lack of flaring)
✓ Welding parameters
✓ Welding operator(s)
✓ NDT results

Recording all the data is good but if you can learn from it then you can really reap the rewards...
To summarise:

What are the benefits to pipeline installation contractors in terms of?

- Quality – better production
- Integrity – improved lifespan
- Schedule – project delivered on time
- Costs – improved efficiency
Thank you for your time.
Please don’t hesitate to ask further questions.