THIS IS CONFIDENTIAL INFORMATION.
THIS DRAWING AND DESIGN IS THE PROPERTY OF LIQUIP INTERNATIONAL PTY LTD.
IT MUST NOT BE COPIED OR REPRODUCED IN ANY WAY WHATSOEVER AND/OR PASSED ON TO ANY THIRD PARTY WITHOUT WRITTEN AUTHORITY.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

TECH TALK 0081
LAN400-25 ADJUSTING BRACKET
04/02/2008

1.0 - Area of concern: In response to enquiries from overseas, modifications have been planned for the Velvet Touch MK2 Loading Arm Adjusting Bracket. It has been observed in the field that the adjustment bolt has been bowing as shown in Figure 1 below. The new design will eliminate this problem.

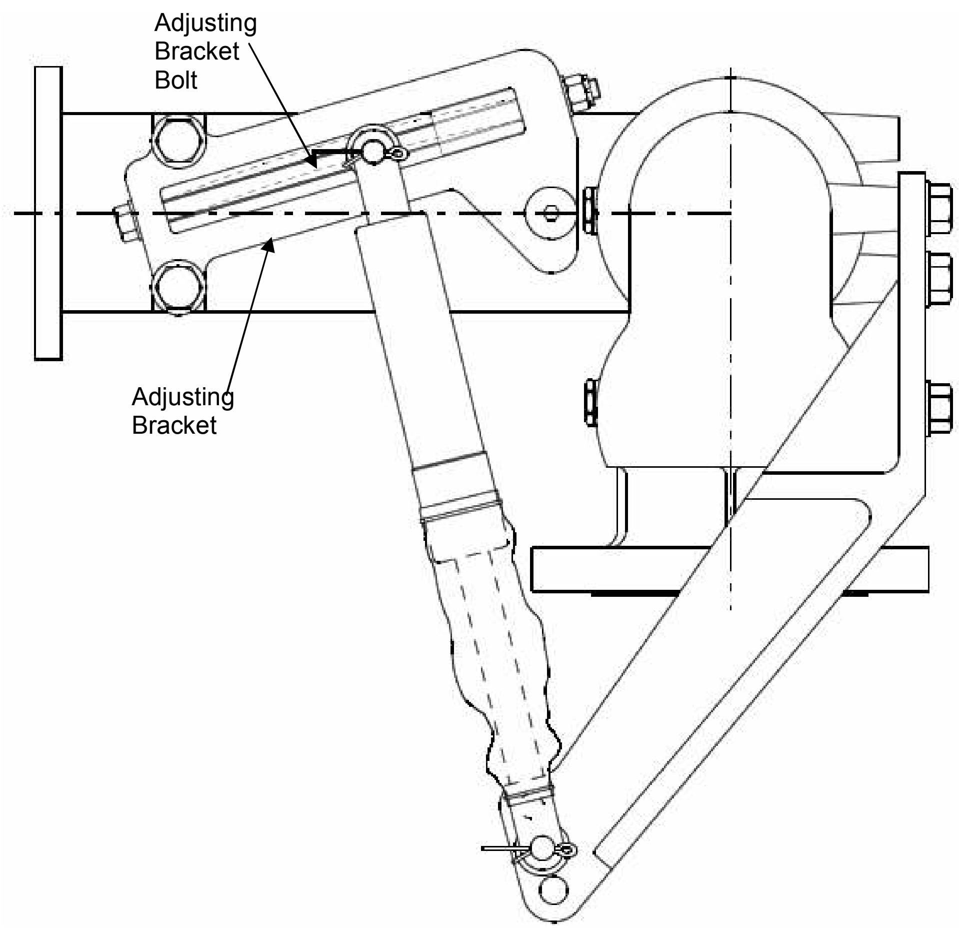


Figure 1: Side view of the Velvet Touch MK2 Loading arm. The buckling of the bolt is represented by the dotted line

2.0 - Bracket Assembly Re-design: Having received feedback from dealers/distributors regarding the above problem, an improved design was sought. There were three components whose design needed to be reviewed.

1. Adjuster Bracket Bolt (Item No. LAN400-23).
2. Adjuster Bracket Pivot Pin (Item No. LAN400-12).
3. Loading Arm Adjuster Bracket (Item No. LAN400-5).

Design concepts for consideration include:

- A square pin as opposed to a round pin will give better load distribution, but will increase the frictional load on the pin.
- A bearing surface must be relatively clean and flat. A cast surface will not suffice.
- Reducing clearances will eliminate the possibility of the adjuster bolt buckling.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

2.1 – Adjuster Bracket Bolt: The changes required for the pin were identified as:

a) Use of a suitable thread that will not strip with increased frictional loads.

At present, a ½" BSW thread is used on all assemblies. An ACME thread was suggested as an alternative, but is not cost effective and some fasteners are not readily available. A UNC thread is easy to find, and will has an appropriate safety factor built in to the design. Calculations can be seen in Appendix A.

As a result of using a UNC thread, components to be changed will be identifiable by a "U" suffix. The new bracket will have the item no. LAN400-5U, the pivot pin will have the item no. LAN400-12U and the adjuster bracket bolt will have the item no. LAN400-23U.

2.2 –Adjuster Bracket Pivot Pin: The changes required for the pin were identified as:

a) A square pin to give better load distribution as opposed to a round pin.
b) Chamfered top edge to act as scraper between pin and bracket.

2.2(a) – Change pin from round to square – In changing the pin design from round to square, the pin will distribute the load more evenly across a surface rather than the line contact of the round pin.

One of the issues in changing the pin design was the sourcing of 25 mm square bar. Previously, Liquip has used an SAF2205 grade stainless steel available only in a 1" diameter round bar. If a square bar of comparable size of the same material is to be used, It would need to be cut from plate.

Another difficulty encountered is the actual material strength. Calculations were performed on the pin, and it was seen that the SAP2205 grade stainless has a narrow factor of safety. It was decided to use STAVAX tool steel, a high strength tool steel that is easy to machine. Calculations for these materials can be seen in Appendix B. Material properties of each steel are in Appendix C.

2.2(b) – Chamfered top edges of square pin – The four edges parallel to the pin axis have been chamfered 1 mm x 45˚. This will act as a scraper for the bearing surface and will keep the bearing face clean of any build-up of grease, dust, etc;

Figure 2: LAN400-12 (left) and LAN400-12U. The square pin is the preferred design as it will distribute a shear load better. Note also the chamfered edges on the square pin.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

2.3 – Loading Arm Adjuster Bracket: The changes required for the bracket were identified as:

a) A machined surface for the square pivot pin to slide on was required.
b) The clearance between the adjuster pin and the bracket (measured as 1 mm) to be reduced to zero.

2.3(a) – Machining the top window surface – As the bracket has an all over draft of 4˚, the top surface needs to be machined flat or “cleaned up”. This is done by milling the surface up to a maximum 2 mm.

2.3(b) – Adjuster Bolt Hole location – To reduce the clearance, the hole locations on the bracket need to be reviewed. It also needs to have a tighter tolerance to ensure smooth running of the pin on the bearing surface. The machine top surface on the window will act as a datum for locating the holes.

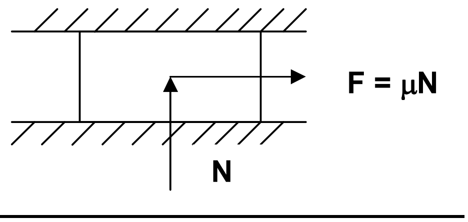
Figure 3: Existing Adjuster Bracket for MK2 Velvet Touch Loading arm. Note the round pin and the 1 mm clearance between the pin and the top edge of the “window”.

Figure 4: Modified Adjuster Bracket assembly for MK2 Velvet Touch Loading arm (LAN400-25).

THIS IS CONFIDENTIAL INFORMATION.
THIS DRAWING AND DESIGN IS THE PROPERTY OF LIQUIP INTERNATIONAL PTY LTD.
IT MUST NOT BE COPIED OR REPRODUCED IN ANY WAY WHATSOEVER AND/OR PASSED ON TO ANY THIRD PARTY WITHOUT WRITTEN AUTHORITY.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

APPENDIX A – LAN400-23U LOAD CALCULATIONS



- F = Force required to move an object (N)
- N = Normal for acting on Pin (N)
  = 2 x 5 200 N
  = 10.4 kN
- μ = Coefficient of Friction
  = 0.8 for Steel on Steel (Clean) [**REF:** Machinery's Handbook – P. 189]

Therefore:

F = 0.8 x 10.4 kN
= 8.32 kN

Check for bolt failure (buckling):

$F_{Cr} = \dfrac{\pi^2 \times E \times I}{L^2}$ [**REF:** Mechanics of Materials (2nd Edition) – R.C. Hibbler– P.662]

Where: - *E* = *Youngs Modulus = 210 GPa*
- *I* = *Second Moment of Area*
= $(\pi/64) \times (12.7^4)$
= $1279.98\ mm^4$
- *L* = *236 mm (Estimated active length)*

$F_{Cr} = \dfrac{\pi^2 \times 210 \times 1279.98}{236^2}$
= 47.52 kN

And for a Safety Factor,

$S_{Buckling}$ = 47.52 ÷ 8.32 kN
= 5.71 ✓

Check for bolt failure (Stripping or yield):

Currently, the load is taken up by a ½" BSW bolt (AS2451). Using Data from

- Yield Load for these bolts = 22.1 kN [**REF:** Ajax Fasteners – Fasteners Handbook – Breaking & Yield Load of Ajax Bolts – P.18]

From this we can obtain a Factor of Safety (S)

THIS IS CONFIDENTIAL INFORMATION.
THIS DRAWING AND DESIGN IS THE PROPERTY OF LIQUIP INTERNATIONAL PTY LTD.
IT MUST NOT BE COPIED OR REPRODUCED IN ANY WAY WHATSOEVER AND/OR PASSED ON TO ANY THIRD PARTY WITHOUT WRITTEN AUTHORITY.

- S_{Yield} = 22.1 kN ÷ 8.32 kN
  = 2.66

A minimum S-value of 5 is required when designing these components, hence the need to choose either an improved thread or a larger diameter bolt. Note the different failure modes for BSW, and UNC threads.

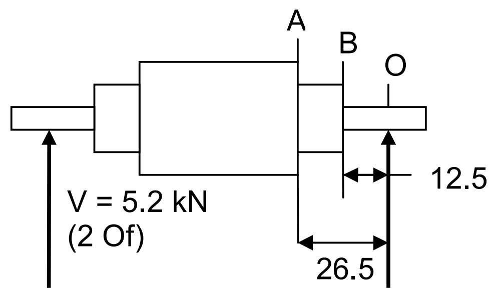
- _Option 1_ – Use a ¾" BSW thread – Yield Load = 53.6 kN ÷ 8.32 kN [S = 6.44] ✓, or
- _Option 2_ – Use a ½" UNC thread – Proof Load = 53.8 kN ÷ 8.32 kN [S = 6.47] ✓, or
- _Option 3_ – Use a ½" ACME thread – Yield Load = 26.0 kN ÷ 8.32 kN [S = 3.13] ×.

To maintain a BSW thread, a ¾"diameter is required. This would mean having to modify both the adjuster pin and bracket casting. The use of a ½" thread in either UNC or ACME would only mean a change to the pin. UNC would be the preferred option in this case. ACME threads have been suggested, but off the shelf parts (shown in calculations above) are only available in low-tensile material. Use of a high tensile material would require special machining, making the option non-cost effective. Additionally, Nyloc nuts are not available as standard parts for ACME threads.

THIS IS CONFIDENTIAL INFORMATION.
THIS DRAWING AND DESIGN IS THE PROPERTY OF LIQUIP INTERNATIONAL PTY LTD.
IT MUST NOT BE COPIED OR REPRODUCED IN ANY WAY WHATSOEVER AND/OR PASSED ON TO ANY THIRD PARTY WITHOUT WRITTEN AUTHORITY.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

APPENDIX B – LAN400-12U LOAD CALCULATIONS



Load Calculations:

Point A: * Load in Shear = 5.2 kN
* Shear Stress (τ) = V/A
= 5200/((π/4)*(15.8^2))
= 26.52 MPa
* Load in Bending = 5.2 kN *26.5 mm
= 137.8 Nm
* Bending Stress (σ) = My/I

$$= \frac{137.8 \text{ Nm} * 0.0079 \text{ m}}{(\pi/64)*(0.0158\text{^}4) \text{ m\^{}4}}$$

= 355.86 MPa

* PRINICIPLE STRESSES = (σ/2)±SQRT[(σ/2)^2+τ^2]
= -1.97, 357.83 MPa

Point B: * Load in Shear = 5.2 kN
* Shear Stress = V/A
= 5200/((π/4)*(13.5^2))
= 36.33 MPa
* Load in Bending = 5.2 kN *12.5 mm
= 65 Nm
* Bending Stress = My/I

$$= \frac{65 \text{ Nm} * 0.00675 \text{ m}}{(\pi/64)*(0.0135\text{^}4) \text{ m\^{}4}}$$

= 269.10 MPa

* PRINICIPLE STRESSES = (σ/2±SQRT[(σ/2)^2+τ^2]
= -4.82, 273.92 MPa

Hence, Critical Point is at A

To determine Stress Concentration Factors:

- r/d = 1/14 = 0.074
- D/d = 15.9/13.5 = 1.178

From tables, K_t = 1.7 [**REF:** Mach. H/Book – 25th Edition – P.200]

THIS IS CONFIDENTIAL INFORMATION.
THIS DRAWING AND DESIGN IS THE PROPERTY OF LIQUIP INTERNATIONAL PTY LTD.
IT MUST NOT BE COPIED OR REPRODUCED IN ANY WAY WHATSOEVER AND/OR PASSED ON TO ANY THIRD PARTY WITHOUT WRITTEN AUTHORITY.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

K = 1 + q*(K_t – 1) [**REF:** Mach. H/Book – 25th Edition – P.198]
= 1 + 0.15(1.7-1)
[Where: q = Sensitivity Factor = 0.15 for Hardened Steel]
= 1.105

Actual Stress = K x PRINCIPAL $STRESS_A$
= 1.105 * 357.83 MPa
= 395.40 MPa

Check for Safety factor in component, by using yield strength:

SANMAC SAF 2250: S = 485/395.40 [**REF:** See Appendix C]
S = 1.23

STAVAX SUPREME: S = 1290/395.40 [**REF:** See Appendix C]
S = 3.26

The *STAVAX SUPREME* Stainless Steel is the preferred option in this instance. The SAF2205 grade is acceptable, but there is little margin for error when using this material as there is a low safety factor.

LIQUIP INTERNATIONAL PTY LTD - ENGINEERING DEPARTMENT - 13 HUME RD SMITHFIELD SYDNEY NSW AUSTRALIA 2164
PH: +61 2 9725 9000 FAX: +61 2 9609 4739 EMAIL: engineering@liquip-nsw.com.au

APPENDIX C – SANMAC SAF2205 VS. STAVAX SUPREME STEEL

	SANMAC SAF 2205	STAVAX SUPREME
Density (kg/m^3)	7800	7740
Young's Modulus at 20˚C (GPa)	200	210
Young's Modulus at 200˚C (GPa)	186	200
Coefficient of Thermal Expansion – Ambient to 200˚C	13.5	11.1
Coefficient of Thermal Expansion – Ambient to 400˚C	14.5	11.7
Thermal Conductivity at 200˚C (W/mK)	17	20
Thermal Conductivity at 400˚C (W/mK)	20	24
Specific Heat at 20˚C (J/kg.K)	480	460
Tensile Strength (MPa)	660-880	1780
Yield Point (MPa) – $R_{P0.2}$	485	1290
Hardened & Tempered	28 HRC	50 HRC