[redacted] Project

Instructions for modelling of various types of Victaulic Coupling

Issue 6, [redacted], 15/Jul/12

These are a consolidation of the "old" instructions (given as replies to queries) and the latest info' from Victaulic.

Rigid Coupling Style-07 (for CS lines DN ≤ 12" & for SS lines DN1.5" (sch5s))

Modelling

Coupling is rigid. Where critical e.g. local to equipment, a rigid element shall be modelled so that the small stiffening effect of the coupling is included.

Tick the "flange" tick-box, and select pressure-equivalent method, so that the summary of loads at the flanges is printed; the flanges are checked against the "old" loads; where "fail" is shown, check against the "new" or "test" loads shown above.

See example model input on page 7.

Loads for use in CS lines are for sch30 pipe in sizes 8" 10" 12" and for standard pipe in other sizes.

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Instructions for modelling of various types of Victaulic Coupling

Rigid Coupling Style-W07 (for CS lines 14" ≤ DN ≤ 24")

Modelling

Coupling is rigid. Where critical e.g. local to equipment, a rigid element shall be modelled so that the small stiffening effect of the coupling is included.

Note that the pressure rating is 25.0barg for all sizes.

Tick the "flange" tick-box, and select pressure-equivalent method, so that the summary of loads at the flanges is printed; the flanges are checked against the "old" loads; where "fail" is shown, check using the "new" formula shown above; assume that the axial force F is compressive.

See example model input on page 7.

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Instructions for modelling of various types of Victaulic Coupling

Rigid Coupling Style-89 (for SS lines 2" ≤ DN ≤ 12")

Modelling

Coupling is rigid. Where critical e.g. local to equipment, a rigid element shall be modelled so that the small stiffening effect of the coupling is included.

Tick the "flange" tick-box, and select pressure-equivalent method, so that the summary of loads at the . flanges is printed; the flanges are checked against the "old" loads; where "fail" is shown, check against the "new" or "test" loads shown above.

Note that the pressure rating is 13.8barg for 2" size (sch5s pipe) and 20.7barg for 3" to 12" sizes (sch10s pipe).

See example model input on page 6.

V.C. styles W07 89 are described as rigid. However, the joints are not truly rigid until pressurised. This can result in deflections or rotational creep effects in the cold condition that are not predicted by Caesar analysis. This should be considered during the design stage for the location of supports.

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Instructions for modelling of various types of Victaulic Coupling

Flexible Coupling Style-770 (for CS lines 26" ≤ DN ≤ 42")

Modelling

Coupling is flexible, so it extends when pressurised, and will rotate if the yield-moment is exceeded.
Reminder : yield-moment = 1.0 x 3.14159 x R^3 x P for bending moment (each axis)
Reminder : yield-moment = μ x 3.14159 x R^3 x P for torsional moment, recommended to use μ = 1.0
The yield-moment for bending was given by Victaulic in meeting 27/06/12; "old" was 1.5 x , "new" is 1.0 x .

To model the extension due to pressure :
Use "zero length EJ" element and axial restraint with gap (use nominal value from the catalogue)
To model the rotation of the coupling :
Use RX2, RY2, or RZ2 restraint, as appropriate, for each bending axis and for the torsion axis.
If coupling is assumed to be rigid about the torsion axis, the restraint may be omitted and the torsional stiffness of the EJ set to rigid; likewise with the bending.
To check that the rotation of the coupling does not exceed the allowable :
Use RX, RY, or RZ restraint, as appropriate, with angular gap (use 75% x nominal value from the catalogue), for each bending axis.
If the yield-moment exceeds the allowable moment, the rotation part of the above modelling may be omitted.

Tick the "flange" tick-box, and select pressure-equivalent method, so that the summary of loads at the flanges is printed; the flanges are checked against the "old" loads; where "fail" is shown for sizes 36" and 42", check against the "new" loads above, where "fail" is shown against other sizes and the force is compressive, check using the formula :
rated_pressure > design_pressure + (16*M)÷(π*D^3) + (4*F)÷(π*D^2), where a compressive force is negative.

See example model input on page 5

Project

Instructions for modelling of various types of Victaulic Coupling

Flexible Coupling Style-77 (for CS lines < DN14")

Allowable loads : Use the "old" catalogue information, as checked by the current spreadsheet.

Size	Ref' only yield-moment (Nm) at 7.6barg	Allowable angulation (°)	gap (mm)	Ref' only "old" M (Nm) at 7.6barg	Pressure rating (barg)
2"	66	0.76	1.6	265	69.0
3"	210	0.52	1.6	847	69.0
4"	446	1.20	3.2	1800	69.0
6"	1423	0.81	3.2	5747	69.0
8"	3139	0.63	3.2	9789	55.0
10"	6079	0.50	3.2	18957	55.0
12"	10142	0.43	3.2	31626	55.0

Modelling

Coupling is flexible, so it extends when pressurised, and will rotate if the yield-moment is exceeded.
Reminder : yield-moment = 1.0 x 3.14159 x R^3 x P for bending moment (each axis)
Reminder : yield-moment = μ x 3.14159 x R^3 x P for torsional moment, recommended to use μ = 1.0
The yield-moment for bending was given by Victaulic in meeting 27/06/12; "old" was 1.5 x , "new" is 1.0 x .

To model the extension due to pressure :
Use "zero length EJ" element and axial restraint with gap (see table above)
To model the rotation of the coupling :
Use RX2, RY2, or RZ2 restraint, as appropriate, for each bending axis and for the torsion axis.
If coupling is assumed to be rigid about the torsion axis, the restraint may be omitted and the torsional stiffness of the EJ set to rigid; likewise with the bending.
To check that the rotation of the coupling does not exceed the allowable :
Use RX, RY, or RZ restraint, as appropriate, with ang' gap (see table above), for each bending axis.
If the yield-moment exceeds the allowable moment, the rotation part of the above modelling may be omitted.

Tick the "flange" tick-box, and select pressure-equivalent method, so that the summary of loads at the . flanges is printed; the flanges are checked against the "old" loads.

See example model input on page 5

For reference only - at 7.6barg these couplings will rotate before the allowable load is reached.
If the design_pressure > rated_pressure ÷ 3, the coupling will rotate only after the allowable load is exceeded.

Flexible Coupling Style-W77 (for CS lines 14" ≤ DN ≤ 24")

Allowable loads : Use the "old" catalogue information, as checked by the current spreadsheet.

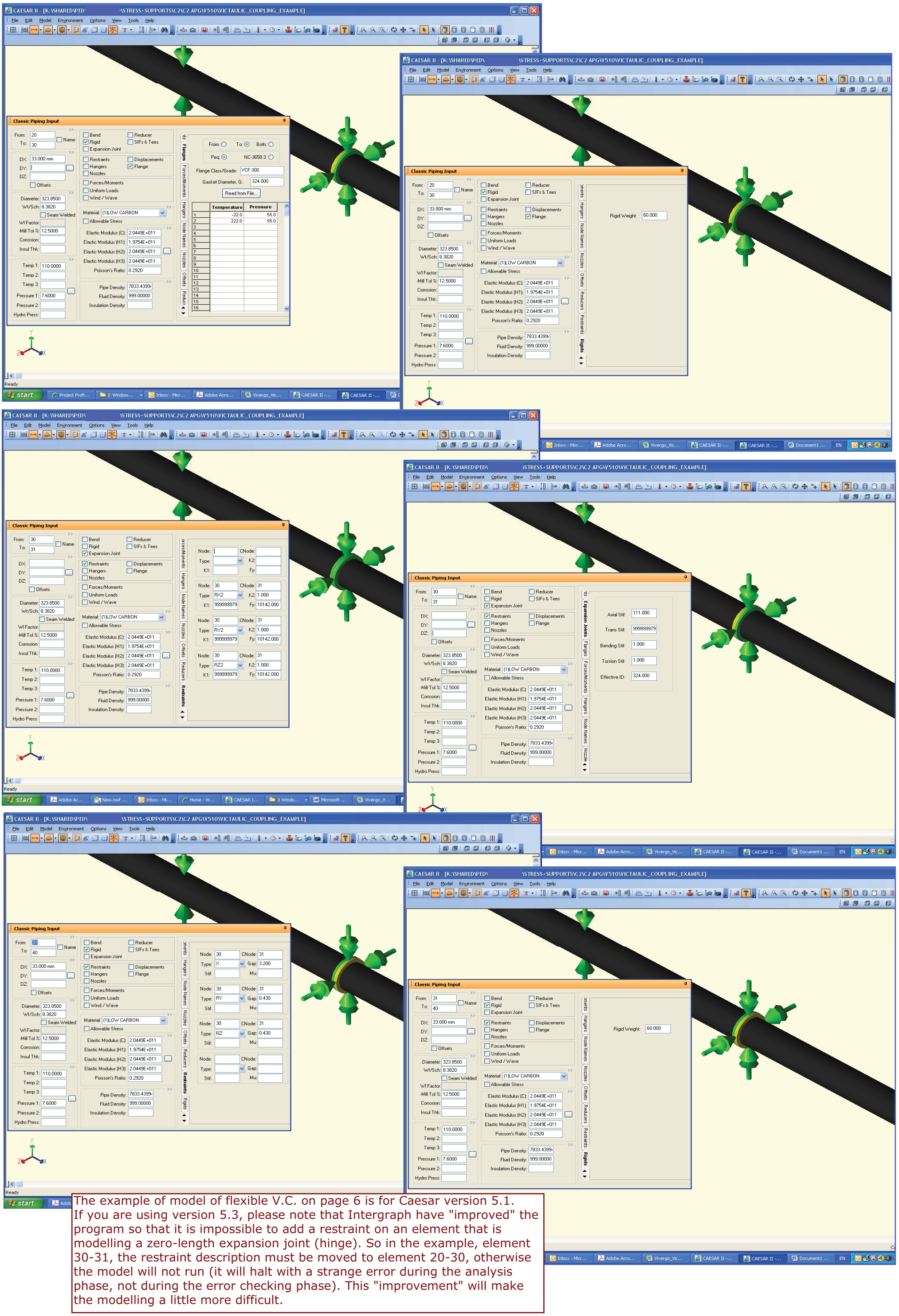
Size	Ref only yield-moment (kNm) at 7.6barg	Allowable angulation (°)	gap (mm)	Ref only "old" BM at 7.6barg	Pressure rating (barg)
14"	13.4	0.55	4.6	15.4	25.0
16"	20.0	0.47	4.6	22.9	25.0
18"	28.5	0.43	4.6	32.7	25.0
20"	39.1	0.38	4.6	44.8	25.0
24"	67.6	0.32	4.6	77.4	25.0

Modelling

As Style-77.

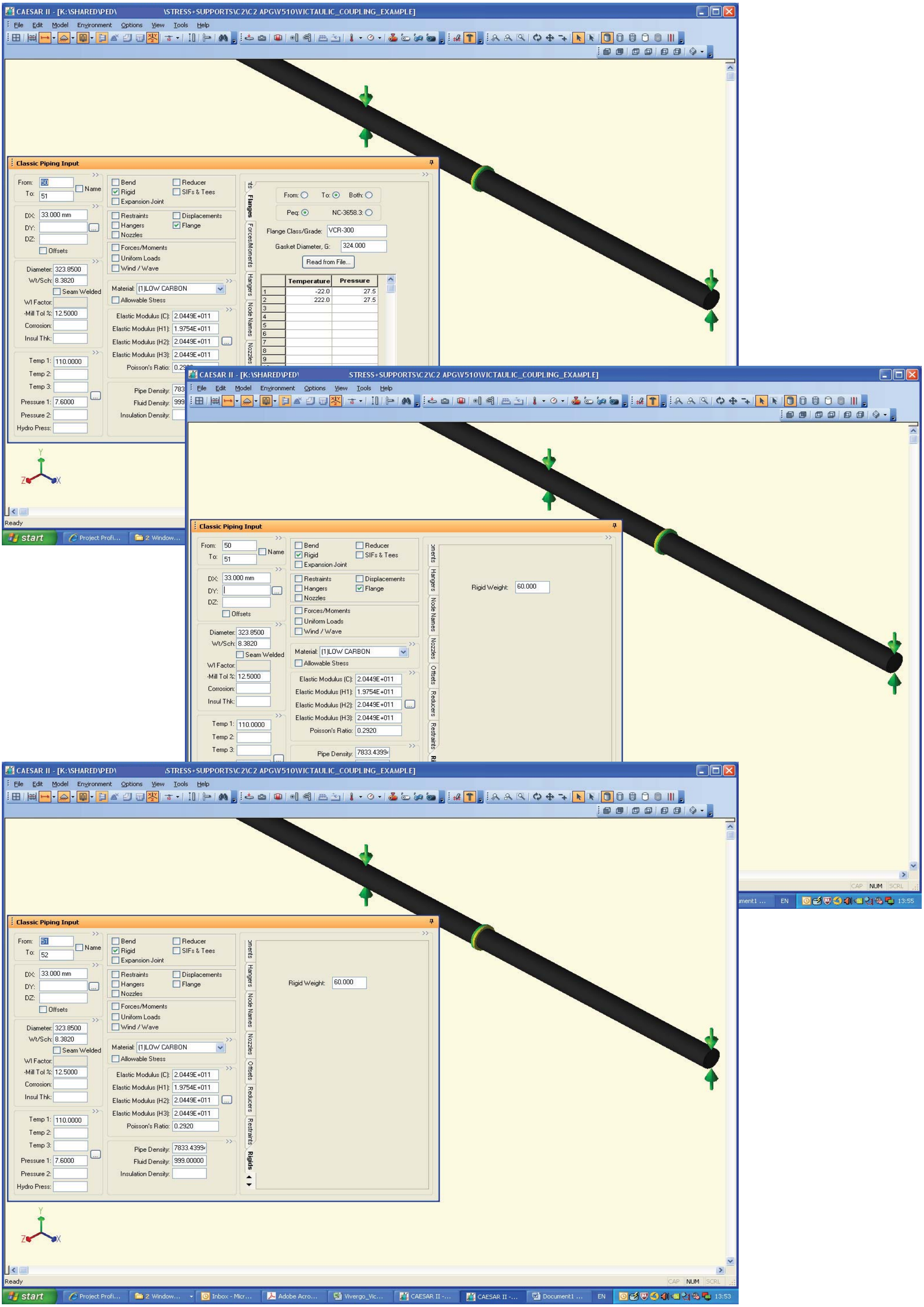
For reference only - at 7.6barg these couplings will rotate before the allowable load is reached.
If the design_pressure > rated_pressure ÷ 3, the coupling will rotate only after the allowable load is exceeded.

Example of model of flexible victaulic coupling



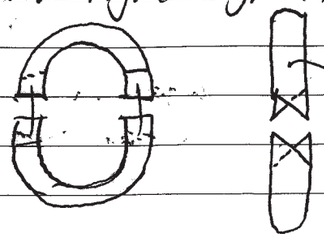
The example of model of flexible V.C. on page 6 is for Caesar version 5.1.
If you are using version 5.3, please note that Intergraph have "improved" the program so that it is impossible to add a restraint on an element that is modelling a zero-length expansion joint (hinge). So in the example, element 30-31, the restraint description must be moved to element 20-30, otherwise the model will not run (it will halt with a strange error during the analysis phase, not during the error checking phase). This "improvement" will make the modelling a little more difficult.

Example of model of rigid victaulic coupling

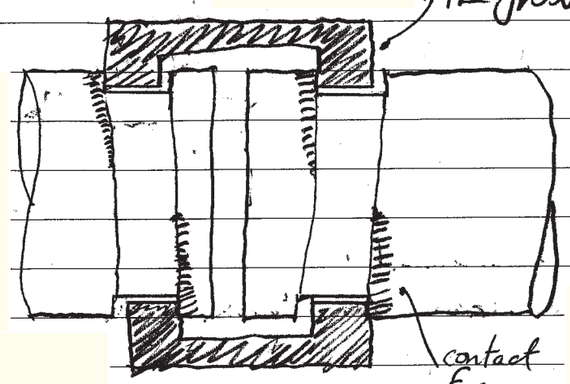


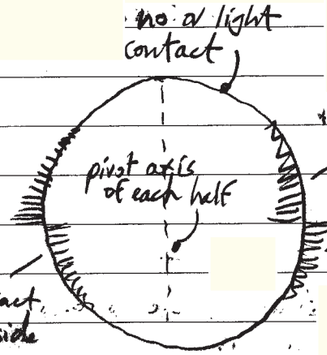
Victaulics – cont'd

see how rigid style 07 is tightened.



each half twists as it is tightened and moves apart to contact one side of the groove





contact far side of groove

contact near side

all loads are transmitted via contact force coupling half ↔ groove

then { contact force between halves of coupling
some shear in bolt }

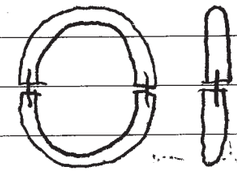
etc

so load path is complex!

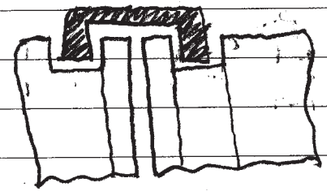
no mention in catalogue of cyclic duty, but SF must be high.

Victaulics cont'd

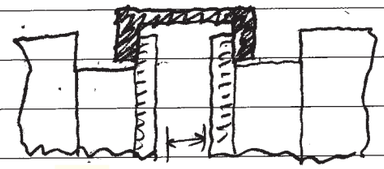
see how Flexible style 770 & 77 is tightened, and think about rotation.



Flat makes contact here before contact with the bottom of the groove



unpressurised
no firm contact



pressurised
pipe moves onto
firm contact

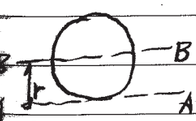
all loads are transmitted
via contact force thro through coupling & not via bolts.
under action of bending moment + pressure, the coupling will
be rigid if pressure dominates
be flexible if moment dominates } derive formula

pressure – even distribution

r = contact radius ≒ limit of pressure

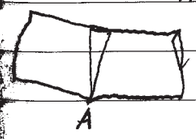
F_L = line load (N/mm) $= \pi r^2 P \div 2\pi r = Pr/2$

moment – uneven distribution – with pivot about pipe radius which is approx' equal to r



for circle about B-B $I_{BB} = \pi r^3 t$ t = imaginary thickness

I_{BB} = area $\times k^2 = 2\pi r t (r^2/2)$



apply parallel axis rule to shift pivot axis to A-A by r

I_{AA} = area $\times (k^2 + r^2) = 2\pi r t (r^2/2 + r^2)$

$= 3\pi r^3 t$ (mm⁴)

now convert to line section modulus $I_{AA,L} = 3\pi r^3$ (mm³)

line load (N/mm) due to moment M

$F_L = M \times r \div I = M/3\pi r^2$

for rotation to commence at a coupling that is fully extended due to pressure, F_L due to M must exceed F_L due to P

$M > 1.5\pi r^3 P$ "yield moment"

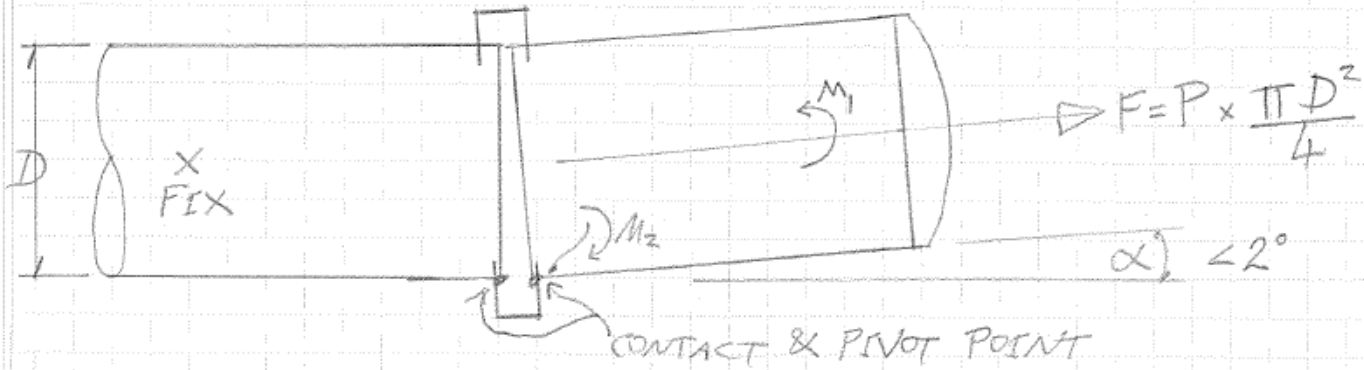
e.g. if $P = 0.5$ N/mm² $r = 200$mm $M > 18.8 \times 10^6$ Nmm $= 18800$ Nm

which is bending stress 25N/mm² if $t = 6.0$.

revised Mar-09. "1.5" was "0.75"
revised Jun-12. now "1.0" as per Victaulic company.

CALCULATION SHEET

Office	Page No.		Cont'n Page No.	264
Job No. & Title FLEXIBLE V&C' COUPLING	Originator	[redacted]	Date	04/07/12
Section YIELD MOMENT	Checker		Date	



IMAGINE PIPING SYSTEM ABOVE IS PRESSURISED TO P AND MOMENT M_1 APPLIED TO "YIELD" THE COUPLING.

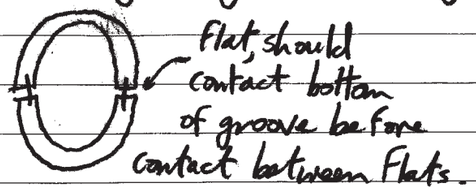
MEASURED AT THE PIVOT POINT, THE MOMENT M_2 DUE TO PRESSURE IS :

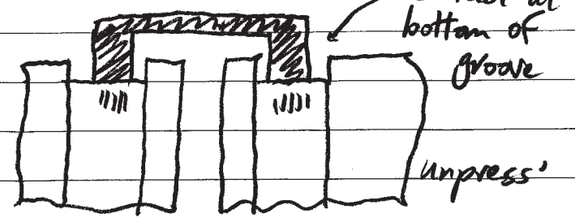
$$M_2 = F \times D/2 = \frac{\pi D^3}{8} P \qquad (\alpha \text{ IS SMALL})$$

HENCE TO KEEP THE COUPLING DEFLECTED

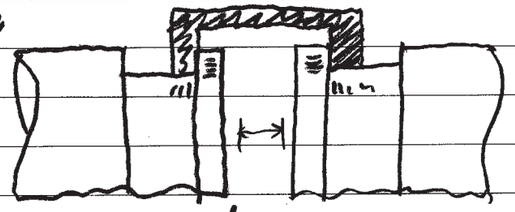
$$M_1 \geq M_2 \quad \text{HENCE} \quad M_1 = \frac{\pi D^3 P}{8} = \pi R^3 P.$$

see how rigid style 89 is tightened.





when "sufficiently pressurised" coupling will slip to make additional contact at side of grooves.
this "pressure at slip" is not required to be calculated.



all loads transmitted through coupling and not bolts, so for cyclic loads should perform better than style-07.

Allowable moments for style 07 & 89,
these are given in catalogue as "permissable end load" which is "...total, from all internal and external loads"
like a flange (pressure equivalent formula) P and M are linked $P_{EQUIV} = \frac{2M}{\pi r^3}$ $P_{TOTAL} = P_{DESIGN} + P_{EQ}$

end load $= P_{TOTAL} \times AREA = \pi r^2 \left(P_{DESIGN} + \frac{2M}{\pi r^3} \right)$

unchecked !

end load $= P_{DESIGN} \times \pi r^2 + \frac{2M}{r}$ compare with catalogue.

e.g. 07-12"NB $r = 162mm$ rated end load 22695ON MAX' PRESS' $2.75 N/mm^2$
say 10barg $= 1.0 N/mm^2$ moment $M = 15 kNm = 15 \times 10^6 Nmm$
EQ' END LOAD $= 1.0 \times \pi r^2 + 2M/r = 82.4kN + 185.2kN = 268kN$
SINCE $268kN > 227kN$ not acceptable. FAIL.
OR USE
$P_{TOTAL} = 1.0 + \frac{2M}{\pi r^3} = 3.2 N/mm^2$ MAX' RATED (catalogue) $= 2.75 N/mm^2$ ∴ FAIL