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CAESAR II ALLOWABLE STRESS INPUT
For UKOOA CODE

In the Caesar II allowable stress input spreadsheet the following fields are available:

Sc	= Not used.	
Sh	= f1 * LTHS	
F	= r	=Sa(0:1)/Sa(2:1)
Eff	= f2	
Sy	= Not used.	
Fac	= k	
Pvar	= Not used.	
Piping code ID		

Sh.

Sh = f1 * LTHS

f1 is the part factor f1 which provides a measure of degree of scatter in the long term pressure tests. Default value is 0.85.

LTHS is the long term hydrostatic strength of pipe determined in accordance with ASTM D2992. For the value refer to the appropriate product data sheet (value for HDB).

F.

F = r = Sa(0:1) / Sa(2:1)

Sa(2:1) is the long term axial strength at the 2:1 condition. For the value refer to the appropriate product data sheet (value for HDB divided by two (2)).

Sa(0:1) is the long term axial strength in the axial direction at the 0:1 condition, calculated according the following formula:

$$Sa(0:1) = Sas(0:1) \times [Sa(2:1) / Sas(2:1)]$$

Sas(2:1) is the short term axial strength at the 2:1 condition. For the value refer to the appropriate product data sheet (value for hoop tensile strength divided by two (2)).

Sas(0:1) is the short term axial strength at the 0:1 condition. For the value refer to the appropriate product data sheet (value for axial tensile strength).

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Eff.

Eff = f2

f2 is the part factor f2 which is a factor of safety for which a default value of 0.67 is usually taken.

Fac.

Fac = k

k is the mean temperature change multiplier as defined in section 7.2.1 of the BS 7159 code. This should be 0.85 for liquids, 0.8 for gases and 1.0 for ambient temperature changes.

Piping code ID.

The piping code ID for the UKOOA code is 28.

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CAESAR II ALLOWABLE STRESS INPUT
UKOOA CODE (20 YEARS)

Bondstrand Epoxy Series (GRE)				
T Dsgn	[redacted]			°C
f1	[redacted]			-
LTHS	[redacted]			N/mm^2
Sh	141.8	141.8	108.7	N/mm^2
Sas(0:1)	80	70.6	65	N/mm^2
Sas(2:1)	110	110.0	110	N/mm^2
Sa(0:1)	59.2	52.3	37.2	N/mm^2
Sa(2:1)	81.4	81.4	63.0	N/mm^2
F(r_)	0.7	0.6	0.6	
Eff (f2)*	0.67 (SUS Loads), 0.83 (OPE Loads) & 0.89 (OCC Loads)			
Fac (k)**	0.85	0.85	0.85	

** Value for liquids.

Prepared on 31st October 2003

We are using UKOOA code, allowable stresses will be checked and verified by the program.

The minimum fitting wall thickness is 1.5 times the pipe wall thickness.

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Methodology of GRE Pipe Stress Analysis

Information required for stress analysis, such as pipe wall thickness and outer diameter, please refer to Bondstrand Pipe Data. The outer diameter (i.e., (minimum total wall thickness x 2) + internal diameter) and minimum structural wall thickness (i.e., exclude liner wall) shall apply during GRE pipe stress analysis. Product mechanical properties can also be found in this section too. Information for weight can be found on Product Dimension Table.

Although the wall thickness for GRE fittings is about 50% thicker than the pipe, no special consideration for fittings is required during stress analysis. The stress engineer can start with a rough analysis and assume fittings are the same thickness as pipe. If the result is ok, the model is complete. If you have areas with high stresses, you need to refine your model by putting in the actual wall thickness at fittings (such as elbows, tees and reducers). However, mechanical properties as well as SIF values are to be maintained.

When using B31.3 as reference piping code, you cannot use the Caesar II allowable stress input. The stress engineer must manually check the stresses against the stress diagram. Alternately, if the stress diagram is not available, Ameron recommends using the simplified stress envelope created by UKOOA allowable stress input file.

Occasional loads like wind and earthquake, should be included in the operation case. To check GRE stress analysis results, stresses and nozzle loads on equipment (pumps, heat exchangers, vessels, etc) at operating, occasional and sustain cases need to be verified. Displacement (so that pipe will not sag more then 0.5" at vertical direction) at operation and sustain cases need to be verified as well.

Typical Input Load*:

1) W+T1+P1 (OPE)	(Operating case with design temperature T1)
2) W+P1 (SUS)	(Sustained case dead weight and design pressure)
3) W+T1+P1+WIN1 (OCC)	(Occasional case with wind)
4) W+T1+P1+U1 (OCC)	(Occasional case with uniform load)

* Load cases for each project shall be determined and specified by EPC contractor.

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CAESAR II MECHANICAL PROPERTIES INPUT
Glass-Reinforced-Epoxy(GRE) MATERIAL

In the Caesar II input spreadsheet the following fields are available to input the mechanical properties of GRE material:

Material #
E MOD/axial
Ea/EH*Vh/a
Pipe wgt
Plastic (FRP) Alpha *1.000.000 (mm./mm./deg)
Plastic (FRP) ratio shear modulus/ Emod (axial)
Plastic (FRP) laminate type (1,2 or 3)
Plastic (FRP) Stress intensification factor

Material #.

Select material no. 20 plastic pipe (FRP) from the material database.

E MOD/ axial.

The axial elastic modulus of Fiberglass Reinforced Plastic (FRP) pipe.
For the value refer to the appropriate product data sheet (value for axial tensile modulus).

Ea/Eh*Vh/a. (equivalent to value Va/h as shown below)

The product of the ratio of the axial to the hoop elastic modulus and Poisson's ratio

Eh is the hoop elastic modulus.

Vh/a is the Poisson's ratio relating the strain in the axial direction due to a stress in the hoop direction.

Va/h is the Poisson's ratio relating the strain in the hoop direction due to a stress in the axial direction. For the value refer to the appropriate product data sheet (value for Poisson's ratio hoop/axial).

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Pipe wgt.

The weight of the pipe on a per unit volume basis. For the value refer to the appropriate product data sheet (value for density).

Plastic (FRP) alpha *1.000.000 (mm./mm./deg)

The thermal expansion coefficient for the FRP pipe. For the value refer to the appropriate product data sheet (value for thermal expansion).

Plastic (FRP) ratio shear modulus/ Emod (axial)

The ratio of the shear modulus (G) to the axial elastic modulus of the FRP pipe.

Plastic (FRP) laminate type (1,2 or 3).

The default laminate type (as defined in the BS 7159 code) of the FRP pipe. The value to be used is three (3).

Plastic (FRP) stress intensification factor

For analysis performed by UKOOA code, use default SIF values computed by Caesar II. If analysis is using B31.3 as the reference piping code, SIF values for elbow, reducer and tee are 2.3, 1.0 and 1.0 respectively.

MECHANICAL PROPERTIES
BONDSTRAND EPOXY SERIES (GRE)
FILAMENT WOUND WITH HELICAL ANGLE OF ±55°

Property	Value	Unit
E modulus axial	12 500	N/mm^2
E modulus hoop	25 200	N/mm^2
Shear modulus	6400	N/mm^2
Poisson's ratio hoop/axial ($V_{h/a}$)	0.40	-
Density	1800	Kg/m^3
Expansion coefficient	18 E-6	mm/mm/°C

Prepared on 10th April 2003
Revised on 16th Jul 2003
Revised on 4th Feb 2004

Project Name : **Iran South Pars 9/10 Onshore Facilities**

System : **Underground & Aboveground GRE Pipes, Fittings and Flanges**
Supplied Loose for Underground, AboveGround Piping

Pipe Size - Thickness (mm)	Non-Pressurised (10 Bar) Our Offer (mm)	16 Bar Our Offer (mm)	18 Bar Our Offer (mm)
1"	3.5	**3.5**	3.5
1.5"	3.5	**3.5**	3.5
2"	3.6	**3.6**	3.6
3"	3.6	**3.6**	3.6
4"	2.30	**3.90**	*3.90*
6"	2.50	**4.60**	*4.60*
8"	3.10	**5.30**	*5.30*
10'	3.50	**6.00**	*6.00*
12"	3.90	**6.70**	*6.70*
14"	4.10	**7.10**	*7.10*
16"	4.50	**7.80**	*7.80*
18'	4.90	**8.30**	*8.30*
20'	5.40	**9.30**	*9.30*
24"	6.30	**10.21**	*10.50*
26"	6.90	**11.20**	
28"	7.40	**12.00**	
30'	7.90	**12.80**	
32"	8.40	**13.60**	
36"	9.30	**15.30**	