Tutorial for Jacketed Piping Modeling and Analysis using CAEPIPE

The following are the Steps to perform Jacketed Piping Modeling and Analysis using CAEPIPE.

General

Jacketed piping is used when the primary state of the pipe contents (fuel, chemicals such as resins, etc.) needs to be maintained at a specific temperature during transport. An outer (jacket) pipe surrounds the inner (core) pipe that contains the operating fluid or the chemical. The jacket provides external heating or cooling as required along the length of the core pipe. The terminology used here is as follows:

- Jacketed piping refers to the entire assembly, i.e., a core pipe with a jacket on the outside.
- Jacket pipe refers only to the outside pipe.
- Core pipe refers only to the inside pipe that contains the operating fluid.

In CAEPIPE, jacketed piping need only be modeled once, not twice (as in some other programs). CAEPIPE models the outer jacket pipe along with the inner core pipe on the Layout window. Each row defines a jacketed piping element. The jacket and the core pipes may have different materials, sections and loads (pressures and temperatures).

Tutorial

Snap shot shown below is a sample model for Jacketed Piping Modeling and Analysis. CAEPIPE model file (.mod) and results file (.res) are saved in the .zip file, which can be downloaded from this Tutorial.

ÞÐ	H Caep	oipe : Layo	out (87) -	[Jacketed	piping.mod	d (C:\'	Т	_		*** Caepipe : Graphics - [JacketedPiping.mod (C:\Tutorials\JacketedPiping)] —	×
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#	Node	Туре	DX (ft'in'')	DY (ft'in'')	DZ (ft'in'')	Mat	Sect	Load	Data 🦯	* Z	^
1	Title =	Jacketed	Piping Tuto	orial						Y w tor	x
2	10	From	-2'6''	9'0''	2'1''				Anchor	*	
3	20	Valve	0'9''			CS	927	L1	Jacket endca		
4	20	Location							Flange		
5	25	Jpipe	1.0755			CS	927	L1			
6	25J	Location							Flange		
7	25J	Location							Flange		
8	30	Jpipe	0'8-1/32''			CS	927	L1	Unreinf tee		
9	300	Location	010 4 1001		_	-			Unreinf tee		
10	50	Jpipe	0'8-1732"			US	928	LI			
11	500	Location							Flange		
12	500	Location	100				000		Flange		
13	60	Jpipe	1.0			LS	928		Spider		
14	500	Location	012 1 2211			000	CD	1.1	Limit stop		
10	70	Jpipe	03-172			LCC	001				
17	75	Jpipe	2 0017			LCS LCS	021		Coider		
10	76	Looption	3.3017			103	331		Limitaton		
19	760	Location							∠iniit stop ⊻ restraint		
20	78	Loipe	5'0''			LCS.	931	11	Spider		
20	781	Location	30				331		Limit stop		
22	80	Jbend	1'0''			CS	931	L1	Lana otop		
23	85	Joipe		-0'5-1/32"		CS	931	L1		N N N N N N N N N N N N N N N N N N N	
24	85J	Location							Flange		
25	85J	Location							Flange		
26	87	Jpipe		-3.5807		CS	931	L1	Spider		
27	87J	Location							Limit stop		
28	90	Jpipe		-3.0989		CS	931	L1	Jacket endca		
29	90	Location							Flange		
30	100	Valve		-0'7''		CS	931	L1	Jacket endca 🔻	✓	~
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Step 1:

First, define materials, sections, and loads required for Jacket and Core elements through Layout window > Misc > Materials/Sections/Loads. Snapshots shown below for section and load names ending with "J" refer to the sections and loads defined for Jacket elements.

	 Caej 	oipe : Lo	bads	(2) -	[Jacket	edPiping	j.res (C:\Tutori	als\09_	lacketed	Piping)]				×
<u>F</u> il	e <u>E</u> d	lit <u>V</u> ie	w g	Option:	s <u>M</u> is	c <u>W</u> ind	dow	<u>H</u> elp								
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1	L1	300	150	300	150	1.8										
2	L1J	334	120	334	120	0.2			Y							
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-0-	• Caepi	pe:Pipe	Secti	ons (10)) - [Jac	ketedPipir	ng.mo	d (C:\Tuto	rials\Jac	ketedPipir	ng)]			-		×
File	e Edit	View	Opt	ions N	1isc W	/indow	Help									
				i (2	н	•									
#	Name	Nom Dia	Sch	DD (inch)	Thk (inch)	H Cor.Al (inch)	M.Tol (%)	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (Ib/ft3)	Lin.Thk (inch)	Soil	^			
#	Name	Nom Dia 3''	Sch	0D (inch) 3.5	Thk (inch) 0.216	H Cor.Al (inch) 0.059055	M.Tol (%) 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (Ib/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2	Name 27 928	Nom Dia 3'' 3''	Sch 40 40	0D (inch) 3.5 3.5	Thk (inch) 0.216 0.216	H Cor.Al (inch) 0.059055 0.059055	M.Tol (%) 12.5 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3	Name 927 928 931	Nom Dia 3" 3"	Sch 40 40 40	OD (inch) 3.5 3.5 1.315	Thk (inch) 0.216 0.216 0.133	H Cor.Al (inch) 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4	Name 927 928 931 933	Nom Dia 3" 3" 1"	Sch 40 40 40 40	OD (inch) 3.5 1.315 1.315	Thk (inch) 0.216 0.133 0.133	Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4 5	Name 327 928 931 933 10J	Nom Dia 3" 1" 1" 4"	Sch 40 40 40 40 40 40	OD (inch) 3.5 1.315 1.315 4.5	Thk (inch) 0.216 0.213 0.133 0.133 0.237	H I Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4 5 6	Name 227 928 931 933 10J 11J	Nom Dia 3" 1" 1" 4" 4"	Sch 40 40 40 40 40 40 40	DD (inch) 3.5 3.5 1.315 1.315 4.5 4.5	Thk (inch) 0.216 0.216 0.133 0.133 0.237 0.237	Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5 12.5 12.5 12.5	Ins.Dens (Ib/ft3)	Ins.Thk (inch) 1.5 1.5	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4 5 6 7	Name 327 928 931 933 10J 11J 14J	Nom Dia 3" 1" 1" 4" 4" 2"	Sch 40 40 40 40 40 40 40 40	OD (inch) 3.5 3.5 1.315 1.315 4.5 4.5 2.375	Thk (inch) 0.216 0.133 0.133 0.237 0.237 0.237	H Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5	 Ins. Dens (Ib/ft3) 8 8 8 	Ins.Thk (inch) 1.5 1.5 1.5	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4 5 6 7 8	Name 327 928 931 933 10J 11J 14J 15J	Nom Dia 3" 1" 1" 4" 4" 2" 2"	Sch 40 40 40 40 40 40 40 40 40 40	OD (inch) 3.5 3.5 1.315 1.315 4.5 4.5 2.375 2.375	Thk (inch) 0.216 0.133 0.133 0.237 0.237 0.237 0.154	Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5	Ins.Dens (lb/lt3) 8 8 8 8 8 8 8 8 8	Ins.Thk (inch) 1.5 1.5 1.5 1.5 1.5	Lin.Dens (Ib/ft3)	Lin.Thk (inch)	Soil	^			
# 1 2 3 4 5 6 7 8 9	Name 327 928 931 933 10J 11J 14J 15J JR	Nom Dia 3" 3" 1" 4" 4" 2" 2" Non Std	Sch 40 40 40 40 40 40 40 40 40	0D (inch) 3.5 3.5 1.315 1.315 4.5 4.5 2.375 2.375 3.4375	Thk (inch) 0.216 0.216 0.133 0.133 0.237 0.237 0.237 0.154 0.154 0.1955	Cor.Al (inch) 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055 0.059055	M.Tol (%) 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5	Ins.Dens (lb/ft3)	Ins.Thk (inch) 1.5 1.5 1.5 1.5 1.5 1.5	Lin.Dens (Ib/ft3)	Lin. Thk (inch)	Soil	^			

Step 2:

While modeling the stress system with jacketed piping, use the element types "JPIPE" and "JBEND" instead of PIPE and BEND. The details for Jacket Pipe and Jacket Bend are given below.

Jacket Pipe

A Jacketed pipe is input by typing "JP" under Type or selecting "Jacketed pipe" from the Element types dialog. The material, section and load specified in the Jacketed Pipe dialog apply to the jacket pipe, while the corresponding ones mentioned on the layout row (next to offsets) apply to the core pipe.

Element Types		?	×	Jacketed pipe from 20 to 25	<
C From	C Slip joint	C Cut pipe			
C Pipe	C Hinge Joint	🔿 Beam		Jacket Material CS 🚽	
C Bend	O Ball joint	C Tie rod			
C Miter bend	C Rigid element	C Location	1	Jacket Section 10J 💌	
C Valve	C Elastic element	C Commer	nt		
C Reducer	Jacketed pipe	C Hydrote:	st load	Jacket Load L1J 💌	
C Bellows	$ \bigcirc $ Jacketed bend				
OK	Cancel			OK Cancel	

The jacket's material, section, and load names are input here (CS, 10J and L1J as shown). CAEPIPE retains the properties of a jacket pipe until changed so there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

In case you are analyzing for wind, it may be more accurate to specify a different load for the core pipe alone that does not specify the Wind load since most of the core pipe is not exposed to Wind load. The same applies to the core pipe insulation if the core pipe does not have insulation.

Jacketed Bend

A Jacketed bend consists of a core bend (with a straight portion of core pipe) surrounded by a jacket bend (with a straight portion of jacket pipe).

A Jacketed bend is input by typing "JB" in the Type column or by selecting "Jacketed bend" from the Element types dialog.

			Jacketed Bend at node 80	×
			Jacket Core Material CS Material CS Section 14J Section 931 Load L1J Load L1	4
Flement Types		7 X	Jacket Bend Radius (inch) Core Bend Radius Core	(inch)
C From C Pipe C Bend C Miter bend C Valve	 Slip joint Hinge Joint Ball joint Rigid element Elastic element 	C Cut pipe C Beam C Tie rod C Location C Comment	Bend Thickness (inch) Jacket Core Intermediate Bend Nodes on Jacket Node at Angle (deg)	
C Bellows	Jacketed pipe Jacketed bend Cancel	•⊘ Hydrotest load	OK Cancel	

Jacket (properties)

The jacket's material, section, and load names are input here. The properties of a jacketed pipe are retained until changed. So, there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

Core (properties)

Presently these properties are disabled. You need to enter them on the layout row under Material, Section and Load.

Bend radius

Separate bend radii may be specified for the core and the jacket pipes. Note that CAEPIPE does not check for interference between the core and the jacket arising out of differently specified bend radii. The bend radius for the core pipe is generally the same as that of the jacket pipe since the two bends are generally concentric. Use the Render feature in the Graphics window to check visually for interference between the core and the jacket.

Bend thickness

Separate bend thicknesses may be specified for the core and the jacket bends, if they are not the same as the default jacket and core section thicknesses.

Intermediate nodes

You can define additional nodes on the outside jacket of a jacketed bend for locating supports. You may also use internal nodes generated by CAEPIPE to locate Data items such as supports, spiders, etc.

Internal nodes

CAEPIPE generates a "J" node for jacket pipes. For example, from node 20 to 25, CAEPIPE generates 20J and a 25J as (internal) jacket nodes (that may be referenced on the layout screen).

Similarly, CAEPIPE generates "C" and "D" nodes for the Jacketed bend on the jacket at the near and far ends of the bend. The core pipe bend has its own "A" and "B" nodes. Example: When you define a Jacketed bend from node 78 to the Tangent Intersection node 80, 80A, 80B (nodes on core bend), 80C and 80D (nodes on jacket) are automatically generated. Nodes (80A, 80C) and (80B and 80D) are coincident only if the core and the jacket pipes have the same bend radii.

The "C" and "D" nodes may be used to specify Data items such as supports, forces, etc. on the jacket.

Step 3:

At nodes where the jacket terminates, the ends of the jacket and core pipes need to be rigidly connected using the "Jacket end cap" data type. See Node 530 as an example in the attached model.

By specifying "Jacket end cap" at a node, CAEPIPE <u>only</u> considers that the core pipe and the jacket are "tied" at that node and NOTHING more. Weld SIF at that node, if desired, should be explicitly added using "Location" type and the Data item "Weld". If your weld type is not listed there, you could specify the weld SIF for that node using the "User SIF" Data item. See Node 135 as an example in the attached model.

Also, "Spiders" need to be input at locations found in the physical assembly. You may have to break up the piping into smaller elements to insert spiders at appropriate locations. For example, see Nodes 76 and 78 from the attached model.

Locations where the "Jacket End Caps" and "Spiders" used in the stress system can be viewed through Layout window > View > List > Jacket connections.

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#	Node	Туре	^						
1	20	End Cap							
2	60	Spider							
3	76	Spider							
4	78	Spider							
5	87	Spider							
6	90	End Cap							
7	100	End Cap							
8	115	Spider							
9	127	Spider							
10	135	End Cap							
11	530	End Cap							
12	1000	End Cap							
13	1010	End Cap							
14	1030	End Cap							
15	2000	End Car	~						

Step 4:

Specify Data items such as a Limit Stops, Flanges, Restraints, etc. on the jacket/core at appropriate locations as required.

Step 5:

At the Branch Nodes 30, 110 and 120, both core pipe and jacket are having an "Unreinforced fabricated tee". Then, the "Unreinforced fabricated tees" on core pipe are to be input at Nodes 30, 110 and 120 using the Data item "Branch SIF", while the jacket "Unreinforced fabricated tees" have to be specified at Nodes 30J, 110J and 120J using "Location" type and the Data item "Branch SIF". At all these nodes (30, 30J, 110, 110J, 120 and 120J), you can also add the weld SIFs, again using the "Location" type and the Data item "Weld" or "User SIF". Please note that CAEPIPE will consider only the higher of the two SIF values (first SIF due to branch and the second SIF due to weld) at these nodes in computing stresses.

Any SIF value specified in the "User SIF" Data item will always overwrite any other SIF value calculated/determined at that node using any other method(s).

-0-	Caep	ipe : Branch SIFs (6) - [Jacket — 🛛 🗙
File	e Edi	t View Options Misc Window Help
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#	Node	Туре
1	30	Unreinforced fabricated tee
2	301	Unreinforced fabricated tee
3	110	Unreinforced fabricated tee
4	11W	Unreinforced fabricated tee
5	120	Unreinforced fabricated tee
6	120J	Unreinforced fabricated tee

Step 6:

Save and Analyze the model through File > Analyze. Upon successful analysis, CAEPIPE display Stresses, Displacements, Element forces, Support loads and Support load summary.

-0-	📲 Caepipe : B31.3 (2018) Code compliance (Sorted stresses — 🛛 🛛 🗙														
<u>F</u> ile	<u>File R</u> esults <u>V</u> iew Options <u>W</u> indow <u>H</u> elp														
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	Sustained Expansion Occasional														
#	Node	SL (psi)	SH (psi)	SL SH	Node	SE (psi)	SA (psi)	<u>SE</u> SA	Node	SL+SO (psi)	SHO (psi)	<u>SL+SO</u> SHO			
1	30/	2820	20000	0.14	135J	33109	30000	1.10	30J	2850	26600	0.11			
2	30	2510	20000	0.13	11W	32784	30000	1.09	30	2511	26600	0.09			
3	115J	1819	20000	0.09	110	20741	30000	0.69	115J	1820	26600	0.07			
4	1030J	1672	20000	0.08	1030J	17424	30000	0.58	103QJ	1672	26600	0.06			
5	90J	1392	20000	0.07	1030	16872	30000	0.56	90J	1392	26600	0.05			
6	87J	1363	20000	0.07	135	16680	30000	0.56	87J	1365	26600	0.05			
7	70J	1348	20000	0.07	120	14925	30000	0.50	70J	1349	26600	0.05			
8	50J	1304	20000	0.07	120J	14377	30000	0.48	50J	1312	26600	0.05			
9	75J	1261	20000	0.06	130C	13765	30000	0.46	75J	1262	26600	0.05			
10	78J	1248	20000	0.06	2000	13573	30000	0.45	25J	1253	26600	0.05			
11	25J	1247	20000	0.06	1020J	11399	30000	0.38	78J	1248	26600	0.05			
12	120J	1245	20000	0.06	1020	9912	30000	0.33	120J	1245	26600	0.05			
13	135J	1242	20000	0.06	80D	9857	30000	0.33	135J	1243	26600	0.05	~		



Jacketed Piping Stresses/Ratios

The default stress contour is for the core piping. CAEPIPE provides an option for you to display the color-coded stress/ratio contour for jacketed piping in the graphics window context menu. Upon selecting the command, Jacket stresses can be seen as shown below:



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<u>F</u> ile	e <u>R</u> esi	ults <u>V</u>	ïew	<u>Option</u>	ns <u>W</u>	(indow	<u>H</u> elp)						
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		Press.	S	ustained	1	E)	pansio	n Lor	0	locasion	al	^		
-	Node	Allow. (psi)	SL (psi)	SH (psi)	SH SH	SE (psi)	SA (psi)	SA SA	SL+SU (psi)	(psi)	SHO			
1	20 25	150 1531	866 616	20000 20000	0.04 0.03	809 690	30000 30000	0.03	867 617	26600 26600	0.03 0.02			
2	20J 25J	120 1354	1041 1247	20000 20000	0.05 0.06	1122 1221	30000 30000	0.04	1043 1253	26600 26600	0.04 0.05			
3	25 30	150 1531	616 2508	20000 20000	0.03 0.13	690 1444	30000 30000	0.02	617 2509	26600 26600	0.02 0.09			
4	25J 30J	120 1354	1247 2776	20000 20000	0.06 0.14	1221 2898	30000 30000	0.04 0.10	1253 2804	26600 26600	0.05 0.11			
5	30 50	150 1531	2510 836	20000 20000	0.13 0.04	1436 295	30000 30000	0.05	2511 837	26600 26600	0.09 0.03			
6	30J 50J	120 1354	2820 1304	20000 20000	0.14 0.07	2297 571	30000 30000	0.08	2850 1312	26600 26600	0.11 0.05			
7	50 60	150 1531	836 232	20000 20000	0.04 0.01	295 93	30000 30000	0.01	837 232	26600 26600	0.03 0.01			
8	50J 60J	120 1354	1304 868	20000 20000	0.07 0.04	571 298	30000 30000	0.02	1312 868	26600 26600	0.05 0.03			
9	60 70	150 1606	344 296	20000 20000	0.02 0.01	250 193	30000 30000	0.01 0.01	344 296	26600 26600	0.01 0.01			
10	60J 70J	120 1338	1000 954	20000 20000	0.05 0.05	559 421	30000 30000	0.02 0.01	1000 955	26600 26600	0.04 0.04	~		
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#				Di	splace	ments (c	lobal)			^				
	Node	X (inch) Y (i	nch) Z	Z (inch) XX (0	deg) (Y	Y (deg) ZZ (de	g)				
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2	20	0.016	-0.0	000 -	0.001	-0.00	67 0.	0048	-0.0033	3				
3	20J	0.016	-0.0	000 -	0.001	-0.00)67 0.	0048	-0.0033	3				
4	25	0.039	-0.0	JO2 -	0.002	-0.01	68 0.	0046	-0.0097	7				
5	25J	0.042	-0.0	102 -	0.002	-0.02	205 0.	0032	-0.0091	_				
5	30	0.053		103 -	0.002	-0.02	31 -0	0021	-0.0130	2				
6	3W	0.058	-0.0	103 -	0.002	-0.02	30 1-0	0027	-0.0128	2				
0	50	0.067	-0.0	105 1	0.002	-0.02	30 -0	10061	-0.0150	2				
10	60	0.074	-0.0	109 0	1 000	.0.02	29 .0	10093	-0.015	÷				
11	601	0.000	-0.0		1 000	.0.02	20 10	10064	-0.0193	2				
12	70	0.095	-0.0		1 000	-0.02	28 .0	10076	-0.0190					
13	70J	0.106	-0.0	010 0	0.000	-0.02	284 -0	.0057	-0.0209	- v				

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4	3						ô	j 🙆	K		-			⇒			4	
#	Node	Tag	FΧ	(lb)	FY	(lb)	FZ	(lb)	Μ×	(ft-lb)	Μ'	' (ft-lb)	ΜZ	(ft-lb)				
1	10		-22	2	-10	1	-48	-482		-334		8	-21	7				
2	135		-13	8	-88	6	-20)	1		23		-13	26				
3	530		32		-54		-61		-78	1	-73	}	-13	4				
4	1030		-21	7	776	6	-44		-9		32		79	3				
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Eile	e <u>R</u> es	ults	Vie	ew <u>(</u>	<u>)</u> pti	ons	<u>W</u> ir	ndow	Н	elp								
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Loa	ad comb	oinatio	n	FX (Ib)	FY (Ib)	FZ (Ib)	MX (ft	:-Ib)	MY (ft	-lb)	MZ (f	t-lb)			
Sus	stained			0		0		-390		·2		390		1				
Op	erating1			-222		-10		-482		-334		478		-217				
Sus	stained	+Wind		1		1		-389		-2		389		1				
Op	erating1	+Win	d	-221		-9		-481		-334		477		-217				
Sus	stained	+Wind	2	0		0		-390		-2		390		1				
Op	erating1	+Win	d 2	-222		-10		-482		-334		478		-217				
Sustained+Wind 3 0						0		-390		-2		390		1				
Operating1+Wind 3 -222			-10		-482		-334		478		-217							
Sustained+Wind 4 0		0		-390		-2		390		1								
Operating1+Wind 4 -222		-10		-482		-334		478		-217								
Maximum 1			1		-389		-2		478		1							
Minimum -222					-10		-482		-334		389		-217					
Allo	wables			0		0		0		0		0		0				