concept engineering

Heat Transfer. **Optimized.**

HTRI MEMBER

Widest Range of Turbulators for Heat Transfer Enhancement

www.conceptengg.com www.pinfintube.com www.allturbulators.com

About Us

Concept Engineering International is a heat transfer focused engineering company with over 90% of its products exported to developed markets including Austria, USA, Australia, UK, Germany, Singapore, Malaysia, Indonesia, Thailand, UAE, Mexico among others. Our range of turbulators is indeed very wide and covers most turbulator types.

Possibilities offered by Turbulators:

1. Correctly used turbulators can make equipment a tenth of its normal size in some instances. In others it makes it significantly smaller. Basically its use is warranted in the following instances:

   a. Where the fluid in the tube is viscous.

   b. The fluid flow in the tube has a low Reynolds number.

   c. All kinds of oil coolers and thermic heaters.

   d. Gasses in the tube.

Product Design and Philosophy

1. We have developed our core products using wire due to its low pressure drop high turbulence characteristics making them the best class of turbulators in the world.

2. Since customers may require other types of turbulators due to legacy issues, user specifications or specialized application, we make other types also. Together we have a large range and pride ourselves on being a one stop shop for turbulators.

Major Types of Turbulators

1. Flexible or Wire Petal Turbulators. (Also called wire matrix turbulators)

2. Rigid Center Rod Wire turbulators. (sometimes soldered to tubes)

3. Finned Hollow Rod type Turbulators.

4. Twisted Tape Turbulators. (Traditional).



Major Applications for Turbulators:

1. Oil Coolers
2. Highly viscous liquids
3. Gas or Air heaters/coolers
4. Static Mixers
5. Falling Film Evaporators
6. Inline reactors
7. Prevention of scale formation on tube walls and reduction of fouling by creation of turbulence.

Basic Principles behind Turbulators:

For Heat exchangers

1. A fluid flowing through a tube unless in turbulent flow tends to form a film at the tube wall which impedes heat transfer.

2. A Turbulator breaks this film and makes the flow turbulent raising the effective Reynolds number. This increases heat transfer in the case of heat exchangers, as well as induces mixing and reactions in inline mixers and reactors.

3. Wire due to its small diameter and cylindrical nature offers comparatively lower resistance while offering a large matrix for interacting with the fluid. It thus gives higher mixing and heat transfer for a lower pressure drop.

4. The turbulence created also greatly reduces fouling as particulate matter does not get deposited on the tube walls but is swept off by the turbulence created.

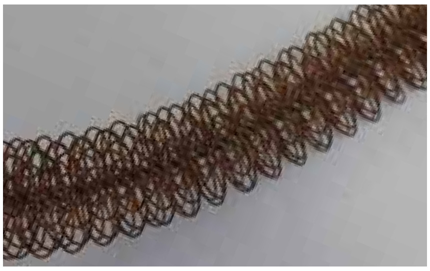
Advantages of Flexible or Wire Petal Turbulators.

(Also called wire matrix turbulators)
-Light weight, flexible and cheap.
-Easy to install, remove and reinsert after cleaning.
-Very efficient.

Range

Size

We can offer for all sizes of tubes from 1/4” to 1.25” OD.



Loop Density

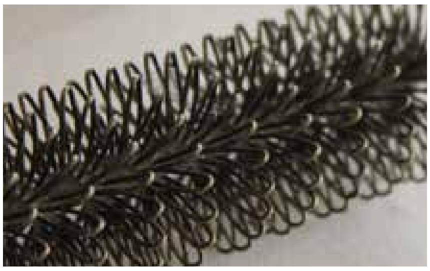
For each tube OD we can offer a wide variety of loop densities from Low Density to Ultra High Density. Apart from our standard range customization of the density can also be done as per customer requirement.

Material of Construction

Stainless Steel 304 / 304L, 316 / 316L, 321 etc.
Carbon Steel.
Copper
Brass
Monel
Fecralloy

Rigid Center Rod Wire Turbulators
(sometimes soldered to tubes)

It is possible to give a high wire loop density on a rigid central rod where the loops are soldered both to the central wire rod as well as if desired the tube wall. This arrangement has the following advantages/ disadvantages.



Advantages

-A very high concentration of loops can be put on the center rod as the loops are Oval rather than circular.
-If the loops are soldered inside the tube, they give very good bonding and so increase heat transfer through conduction in addition to through turbulation.
-If soldered inside tubes, this turbulator can withstand high pressure.
-Can be offered in most materials of construction except aluminium.

Disadvantages

-Higher cost.
-Once installed, cannot be removed, as turbulators are brazed/soldered in tubes.
-Solder will melt at temperatures around 180 /290 degrees C for normal/High temperature solder. Hence not suitable for higher applications above 290 degrees C.

Finned Hollow Rod Type Turbulators

For large diameter tubes, it is sometimes desirable to block the center of the tube, to narrow the passage. In such a case we can offer a hollow rod type Turbulator. In this case we substitute the rigid center rod for a small diameter tube the ends of which have been sealed. This sealing of the ends converts the small diameter tube into a light weight hollow rod. The loops are then soldered on just like in the Rigid center rod type Turbulator. This type of Turbulator is generally used in tubes where the id of the tube is more than one inch.

Twisted Tape Turbulators

The twisted tape is the old war horse of the Turbulator world and of course we make them in large quantities. This type is also featured in major heat transfer software as a generic product so customers can do their own design. (A type of wire Turbulator is also featured but as a proprietory product of a UK company and customized as per their configurations.) We can give all standard and a large range of custom pitches and offer them in almost all materials.

While in most cases the flexible wire type is a preferred option, in the case of retrofitting, where there is a lower flexibility with regards to redesigning the existing equipment, this is very often a low pressure drop reasonable efficiency solution.

Other Applications:

Liquid Cooled Heat Sinks for Power Electronics

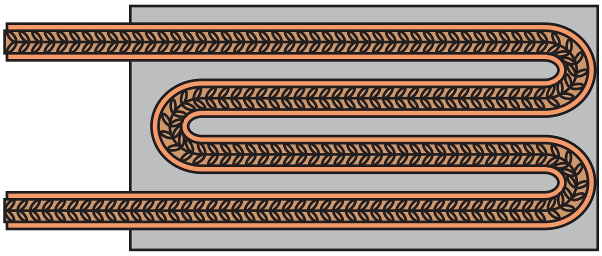
When cooling IGBT modules and high-powered semiconductors, air cooling is often inadequate and liquid cooling is the order of the day. This is because water's thermal conductivity is about 24x of air.

Cold plates are a way to implement localized cooling of power electronics by transferring heat from the device to a liquid that flows to a remote heat exchanger and dissipates into either the ambient or to another liquid in a secondary cooling system.

The application of turbulators increases the rate of heat transfer further, leading to even more heat dissipation than the industry standard and the enhancement is on trend with many thermal solutions' companies looking to capitalize on the improvements in liquid cooling and the customer perception that it's now more reliable and leakproof than ever before.

Applications that call out for liquid cooling further enhanced by our turbulators would be:

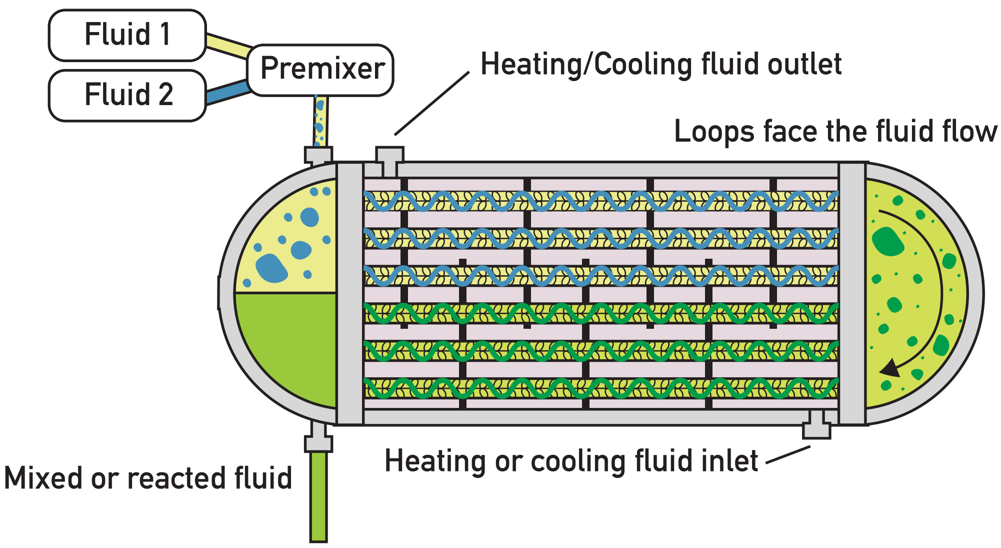
High-powered Electronics
IGBT Modules.
Lasers.
Wind Turbines.
Motor Devices.
Automotive Components.
Medical Equipment.



Inline Static Mixer Reactors

Agitated vessels for mixing or reactions can be replaced by passing the fluids to be mixed through a set of turbulated tubes.

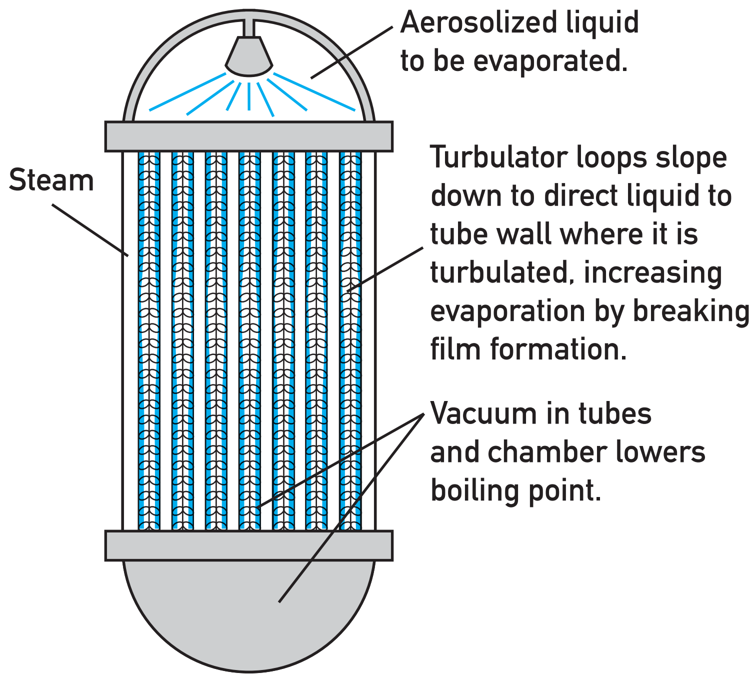
By this in-tube micromixing it is possible to achieve:
1. Online vs batch mixing and reactions.
2. Significantly lower equipment size.
3. Significantly lower power consumption.
4. Significantly lower mixing time.
5. For reactions it is possible to coat turbulators with catalysts or make them from catalyzing metals.
6. For reactions it is possible to add or remove heat by housing the turbulated tubes within an exchanger where the heat transfer fluid (either heating or cooling) can be passed through the shell. (steam, hot/cold water, thermic oil).
7. Turbulators are also very useful when fluids need to be mixed in the feed pipe itself before entering a process chamber.



Falling Film Evaporators

When placed correctly in the tubes of a falling film evaporator, the loops direct the falling liquid to the wall of the tube and also turbulate the film of liquid increasing heat transfer and evaporation.

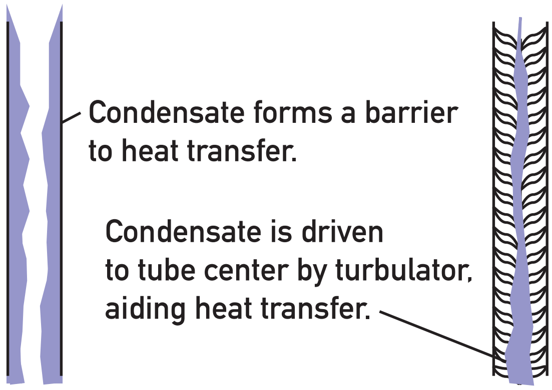
The turbulators also provide additional surface area for the evaporation to take place.



Condensate Drains

Where condensation happens inside vertical tubes, significant performance enhancement is achieved using flexible wire petal turbulators inserted with the loops facing upwards. This is because the condensate film forms a laminar layer impeding heat transfer. The turbulator breaks the film and increases heat transfer and hence condensation. The condensate is diverted to the center of the tube removing its barrier-forming potential significantly increasing the heat transfer at the tube wall. The contact points of the turbulator and tube encourages drop formation at those points. These drops of condensate are drained away towards the center of the tube by the wire loops.

This system is superior to putting the tubes horizontally as in such an arrangement the condensate settles at the floor of the tube reducing effective heat transfer area and in the case of steam condensate can cause knocking.



Further Use Cases

Bearing Oil Coolers
Glycol Coolers
Many others

We can consult with you on your applications. You can also draw on the more extensive data found on our website.

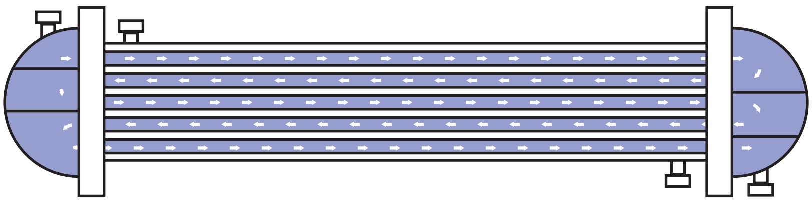
Use Case 2: Shell and Tube Exchangers

A shell and tube exchanger gives a designer many options as he is able to switch the fluids around, vary tube passes as well as baffle arrangements to achieve the desired goal of balancing the heat transfer on the two sides. That said, turbulators can greatly reduce the size of exchangers. It is a very useful tool in the following cases.

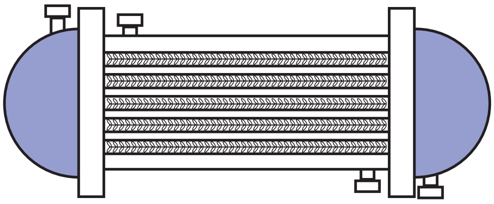
1. Where the tubeside coefficient is lower than the shell side coefficient. Using turbulators will greatly reduce equipment size.

2. Where though initially the tubeside coefficient is higher, with fouling it drops below the shellside performance. Here the tubeside performance is boosted and provides a fouling buffer. Our experience with retrofitting at refineries has showed that due to turbulation the fouling rate and resulting fouling thickness is substantially reduced by using turbulators. This increases exchanger performance as well as time between cleanings. In one case where an equipment was required to be cleaned every 2 months after retrofitting it was running continuously for 2 years at a higher performance level then before.

3. Where the velocity is at its recommended limit and increasing tube passes is not possible. Here one can reduce the passes/velocity by installing turbulators which increase the heat transfer substantially reducing the exchanger size and cost.



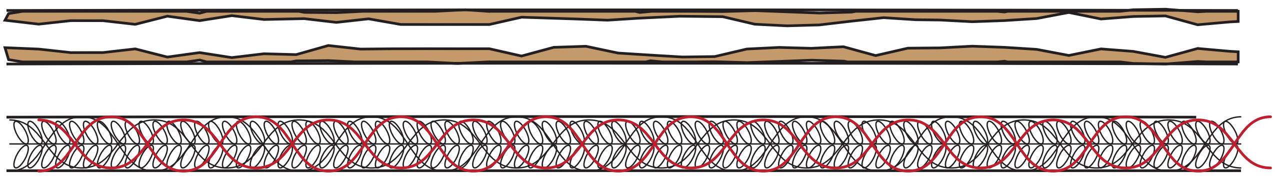
Size Without Turbulator



Size With Turbulator

Use in Fouling Reduction

Fouling buildup on tube wall impedes heat transfer.



Turbulence reduces fouling buildup.

Fouling happens when:

1. The temperature difference at the tube wall leads to changes in the fluid which cause fouling compounds to separate and deposit on tube walls. This can be similar to milk solids sticking to the bottom of a pan of heated milk which has not been stirred while heating.

2. A laminar flow allows particles separated from the fluid to settle on a tube wall.

With a turbulent flow the particles are whisked away before they can form or settle on a tube wall. Hence the fouling reduction caused by turbulators.

Key Aspects of Good Turbulator Design

While we stand ready, and prefer to help our customers with design, we have tried to present an overview by presenting some graphical data.

To do this we have done the following:

Chosen a ¾” OD tube as it is very widely used.

For this tube OD, we prepared the following data:

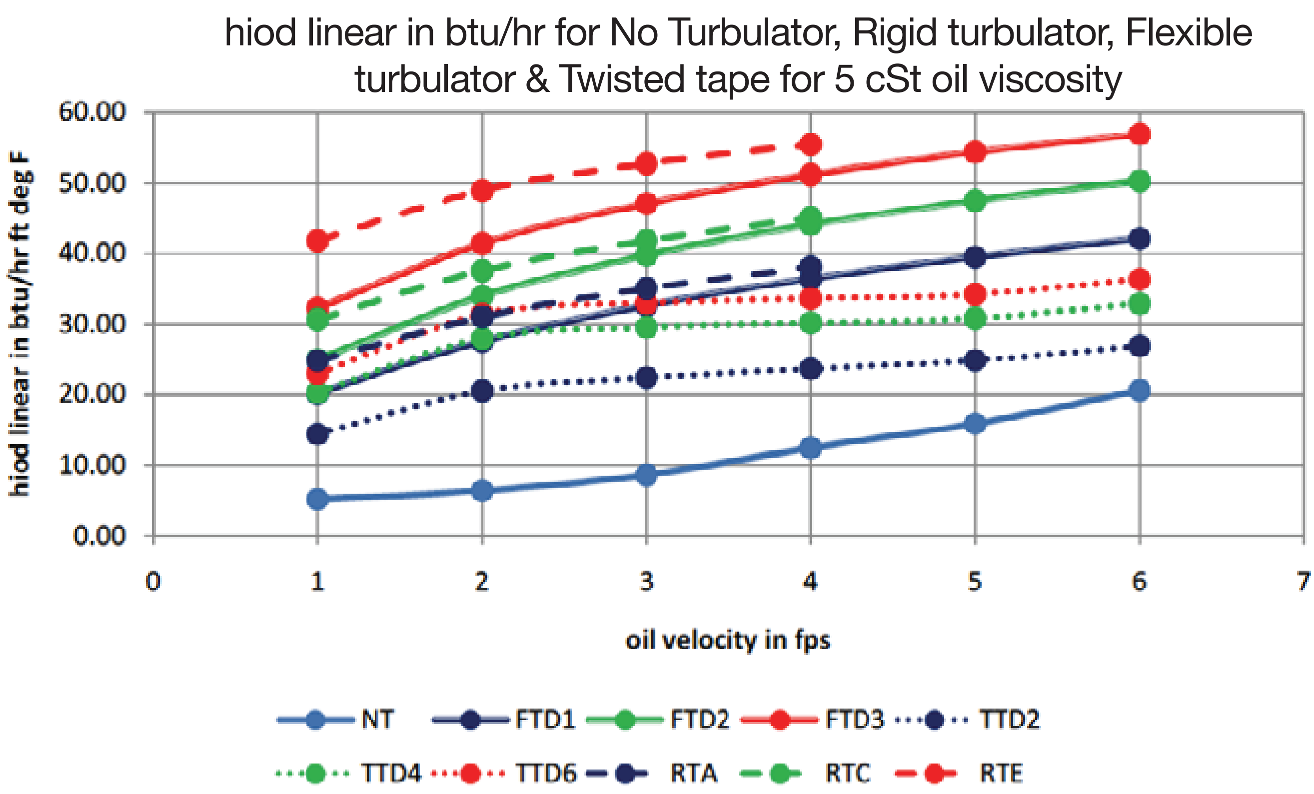
The pressure drop and heat transfer of oil of 3 viscosities, 5 CST, 15 CST and 25 CST travelling through the tubes at a flow rate of 1 to 6 feet per second. This data was prepared for the following Turbulator cases:

• No Turbulator (NT)

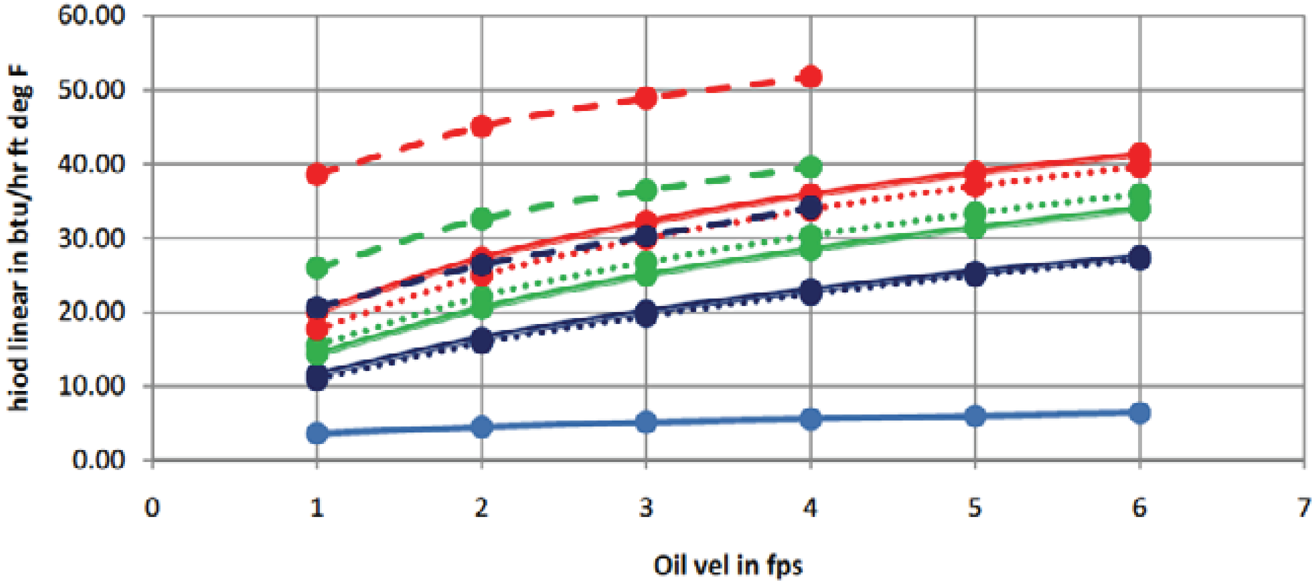
• Rigid turbulators RTA, RTB & RTC. (Our standards for this tube size).

• Flexible turbulators FTD1, FTD2 & FTD3 (Again our standard models) • Twisted tape turbulators. Since the possibilities here are infinite for the case of better comparing the two,we selected those twisted tape turbulators that gave with a 15 CST oil the same pressure drop at 3 FPS flow rate as the corresponding standard flexible turbulators. We must bear in mind though, that twisted tape turbulators thus selected have a very high twist ratio and are not commonly manufactured. However they were chosen for their value in comparision. Most commonly used twisted tape turbulators will have a lower performance and pressure drop.

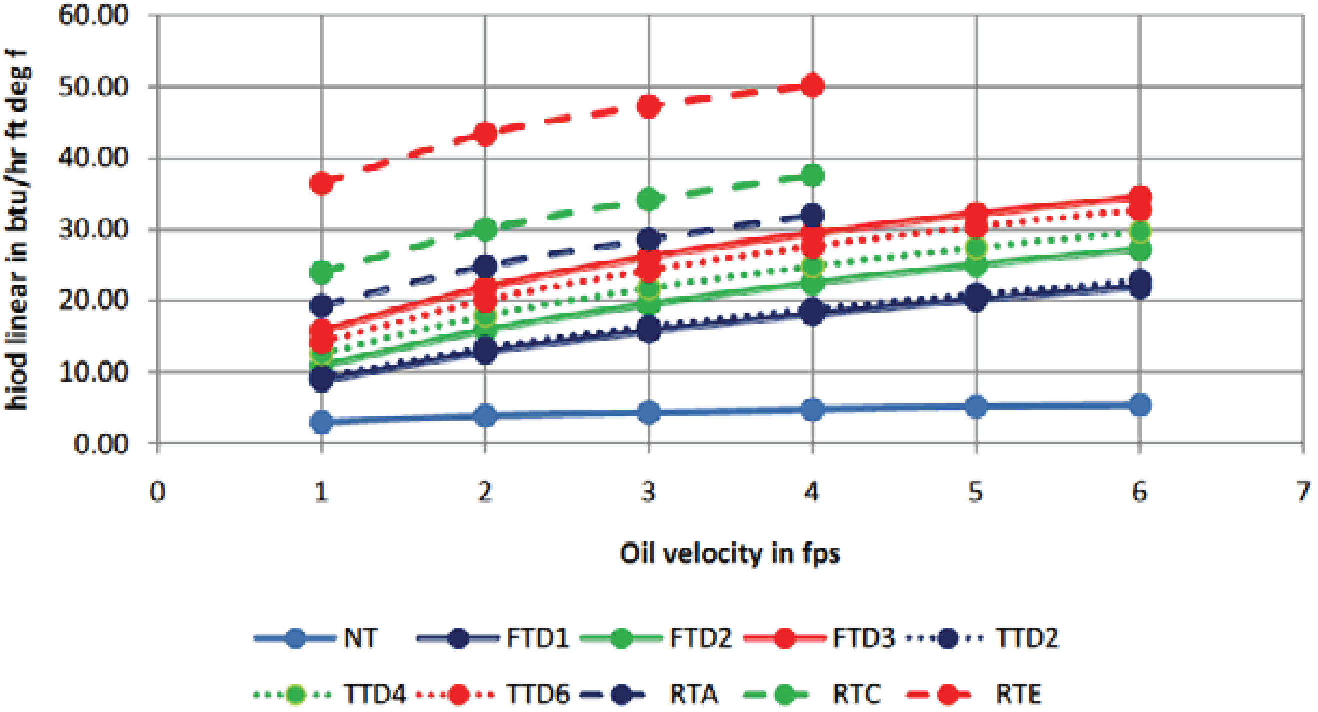
• This data is represented graphically in the following charts/graphs.



hiod linear in btu/hr for No Turbulator, Rigid turbulator, Flexible turbulator & Twisted tape for 15 cSt oil viscosity



hiod linear in btu/hr for No Turbulator, Rigid turbulator, Flexible turbulator & Twisted tape for 25 cSt oil viscosity



HTPD factors for Flexible,Twisted tape & Rigid turbulators												
vel fps	NT	FTD1	FTD2	FTD3		TTD2	TTD4	TTD6		RTA	RTC	RTE
1	500.5	161.5	75.2	58.0		55.2	41.3	31.2		155.3	51.1	41.8
2	195.5	62.0	32.4	23.6		40.2	25.9	18.4		45.6	28.9	15.3
3	132.3	33.2	17.8	12.4		37.2	19.7	13.3		22.6	14.9	8.5
4	112.9	21.4	11.2	7.5		26.1	13.6	9.2		13.4	9.0	5.7
5	100.8	15.4	7.8	5.0		21.5	10.5	7.0				
6	93.6	12.0	5.7	3.5		17.9	8.6	5.8			5 cSt	
vel fps	NT	FTD1	FTD2	FTD3		TTD2	TTD4	TTD6		RTA	RTC	RTE
1	119.4	37.5	15.9	13.9		29.6	20.2	14.7		72.5	28.9	24.1
2	72.2	27.3	11.9	9.5		20.5	12.1	8.4		26.9	20.4	10.7
3	53.6	17.9	8.4	6.4		17.3	9.0	6.0		14.1	11.0	6.6
4	38.1	12.4	6.1	4.6		13.2	6.8	4.6		9.8	7.3	4.6
5	27.9	9.0	4.6	3.4		11.1	5.6	3.7				
6	21.7	6.9	3.6	2.6		9.3	4.7	3.1			15 cSt	
vel fps	NT	FTD1	FTD2	FTD3		TTD2	TTD4	TTD6		RTA	RTC	RTE
1	57.9	11.1	5.2	5.2		20.1	13.0	9.2		52.2	20.0	18.2
2	39.0	13.2	5.5	4.7		13.9	7.7	5.3		20.7	16.7	8.9
3	27.8	10.7	4.6	3.7		11.4	5.7	3.8		12.2	9.8	5.6
4	23.5	8.3	3.7	2.9		8.7	4.3	2.9		8.4	6.6	4.2
5	19.3	6.5	3.0	2.3		7.3	3.5	2.3				
6	15.6	5.1	2.5	1.9		6.1	3.0	1.9			25 cSt	
Note : HTPD factor is calculated for light , medium and dense turbulators as heat transfer coefficient hiod linear per unit pr drop at different oil viscosities and different oil velocities through tubes												
			Good			Better			Best			

The following facts emerge:

1) Across all Turbulator types the HTPD factor goes down as the velocity increases.

2) Across all turbulator types the HTPD factor goes down as the winding density increases.

3) Different Turbulator types give comparatively different results under different viscosity and flow conditions.

4) We can conclude that the best Turbulator is case specific.

The following should be kept in mind:

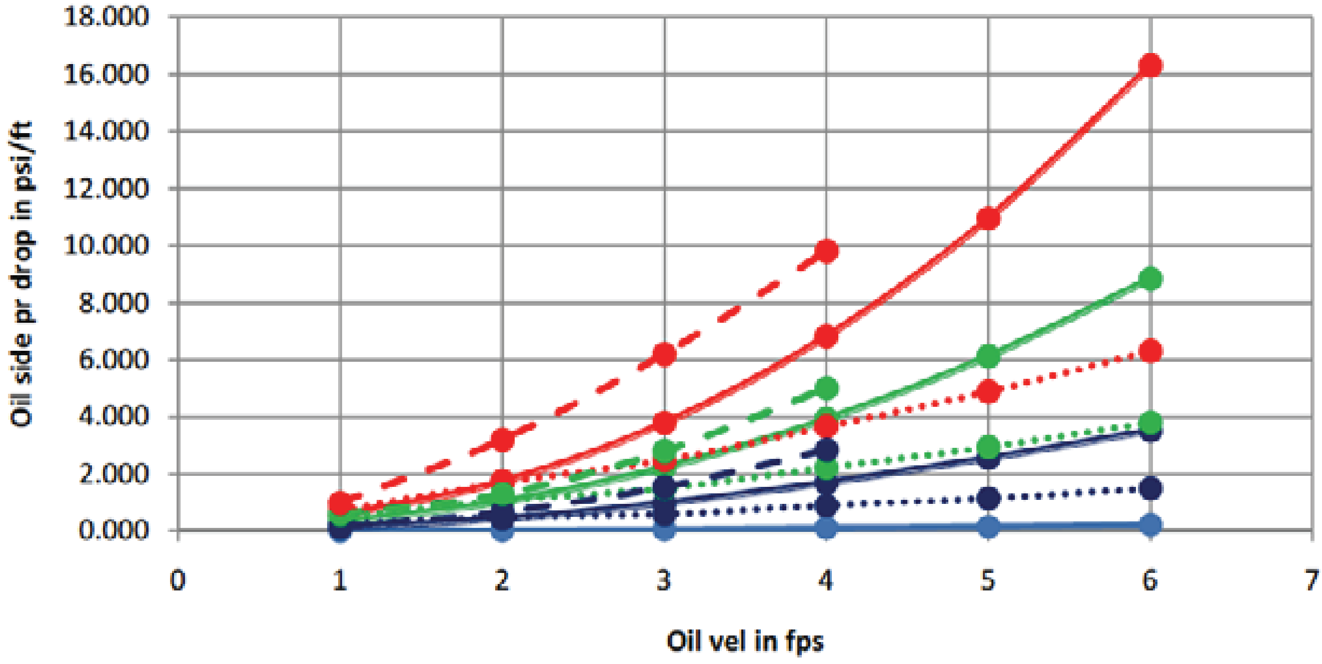
1) The data for rigid turbulators are for rigid soldered turbulators. If the same turbulators are not soldered they perform but not as well. This is due to the better contact and so better heat transfer due to soldering.

2) Just as pressure drop is a cost we pay for performance so is the dollar cost of material and labour. The rigid soldered Turbulator while an extremely efficient Turbulator is expensive to make and install.

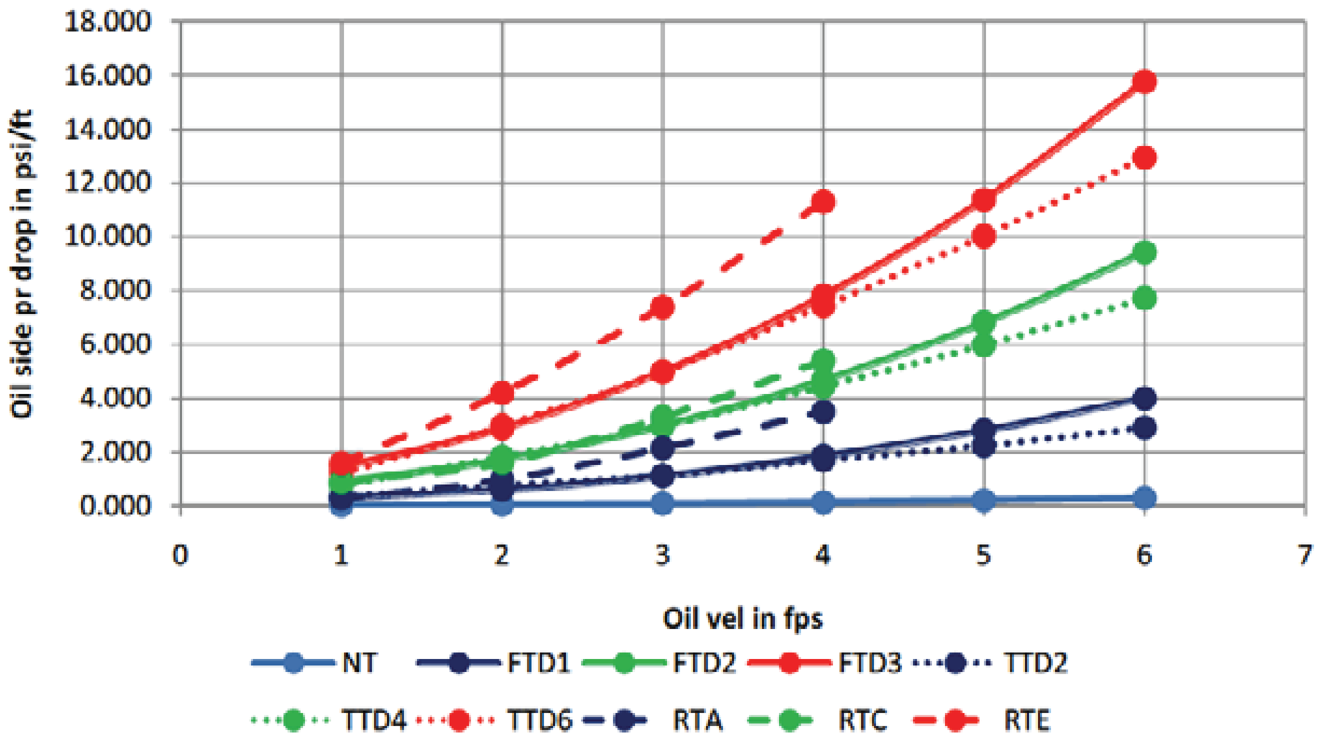
3) Ease of cleaning and maintenance are also key factors in turbulator choice.

4) Since we make all types, we have nothing to lose in giving the client correct advice.

Oil side pr drop in psi/ft for No Turbulator, Rigid turbulator, Flexible turbulator & Twisted tape for 5 cSt oil viscosity



Oil side pr drop in psi/ft for No Turbulator, Rigid turbulator, Flexible turbulator & Twisted tape for 15 cSt oil viscosity



Design

We can assist with the design data for the turbulators we produce on a case by case basis depending on the application, type of turbulators requested and the fluids involved.

Our regular customers are also provided data which they can use for doing their own design.

Customization

To a large degree we can customize our turbulators to meet your requirement.

Research Assistance

For customers wishing to experiment with new applications using turbulators, we are very happy to share our experience and provide support by way of small customized orders shipped by courier.

Example 1 : Brine cooled Air cooler

Here we have as case 1, wire wound fin tube (a special high performance fin tube we make) with no turbulators. In case 2 we have the same wire wound fin tube with internal flexible turbulators. This allows us to see the standalone effect of the turbulators.

Number of rows drops from 20 to 12. Total tube length falls from 1164 to 636. This is a 45% decrease.

Quite naturally the airside pressure drop falls with its commensurate power savings from 1.2 inches of water column to .8 inches. Evan more remarkably the tubeside pressure drop falls from .5 to .4 kgs per square cm. This demonstrates that though the pressure drop goes up nominally on account of turbulators the actual total pressure drop can actually fall as the number of passes reduce and the length of tube becomes less.

Example 2 : Produced Water heater.

Here we have case 1 as a normal helical fin tube with no Turbulator and 6 passes and case 2 our own wire wound fin tube (a much higher efficiency fin tube we make) and our flexible Turbulator inside the tube. The results are given as under.

The surface area of fins per linear foot of wire wound fin tube is 4.02 feet against 6.16 for the normal helical fin tube.

The number of tube rows is reduced from 6 to 3 and tube passes from 6 to 1.

Total fin surface area is reduced from 30,532 to 11,898. A reduction of 62%.

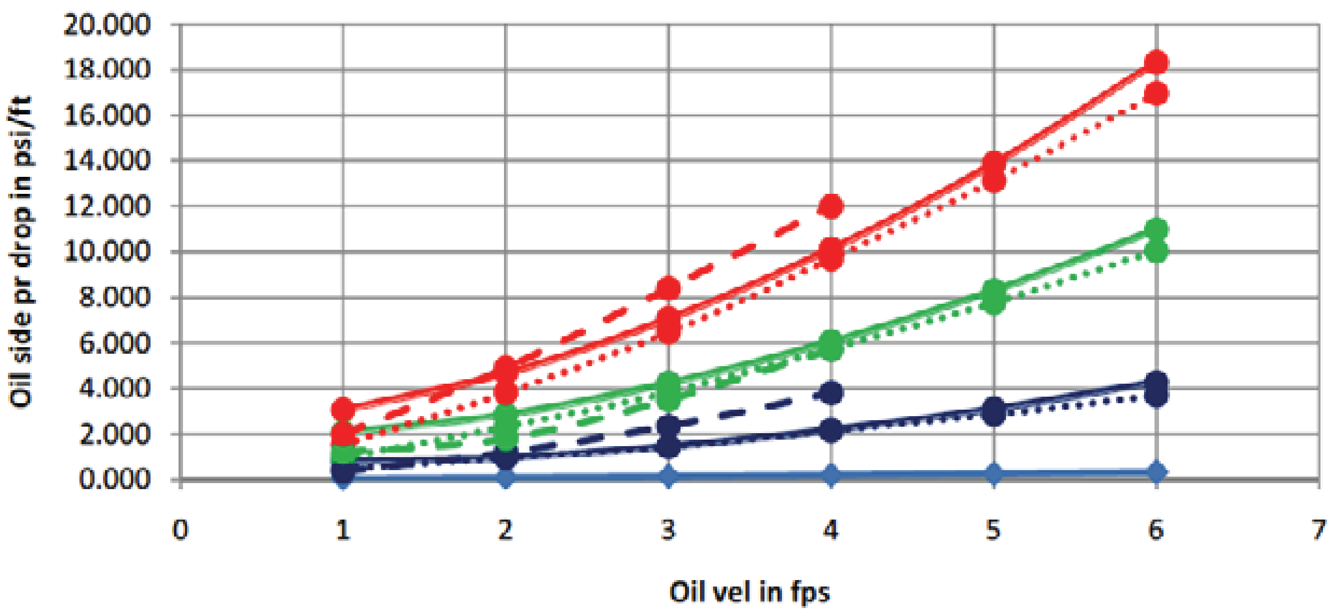
Example 3 : Shell and Tube exchanger (with Hot Oil on the tubeside and Produced water on the shell side.)

Case 1 is without turbulators and case 2 is with flexible internal turbulators.

The total length of tubes is reduced from 55 lengths of 16 ft to 60 lengths of 10 ft.

This reduces the total length of tubes by 32%.

Oil side pr drop in psi/ft for No Turbulator, Rigid turbulator, Flexible turbulator & Twisted tape for 25 cSt oil viscosity



From the curves, we can arrive at the following observations:

1) The rigid soldered turbulators overall give the best heat transfer and also the highest pressure drop. However as the viscosity goes up, the performance as compared to flexible turbulator goes up significantly. For example in the 5 cSt case, RT6 is above FTD3, RT4 above FTD2 and RT2 above FTD1. However at 15 cSt both RT6 and RT4 are above FTD 3 and RT2 is very close to FTD 3. In the case of 25 cST all the three rigid turbulators are all above the highest performing flexible turbulators.The pressure drop is also compared to performance much lower.

2) The performance of the twisted tape (even though the twisting selected is high to match the pressure drop of corresponding flexible wire Turbulator) is generally lower than that of the flexible but not by much. However given that we will not have such a high degree of twisting in standard available twisted tape turbulators we can say that the flexible turbulators perform better.

3) The pressure drop increase for the two wire type turbulators with increase in fluid velocity is more than linear. The increase in performance is less than linear. This tells us that after a point it is not worth trying to purchase performance with pressure drop.

4) The performance as well as the pressure drop in the case of twisted tape turbulators are more linear.

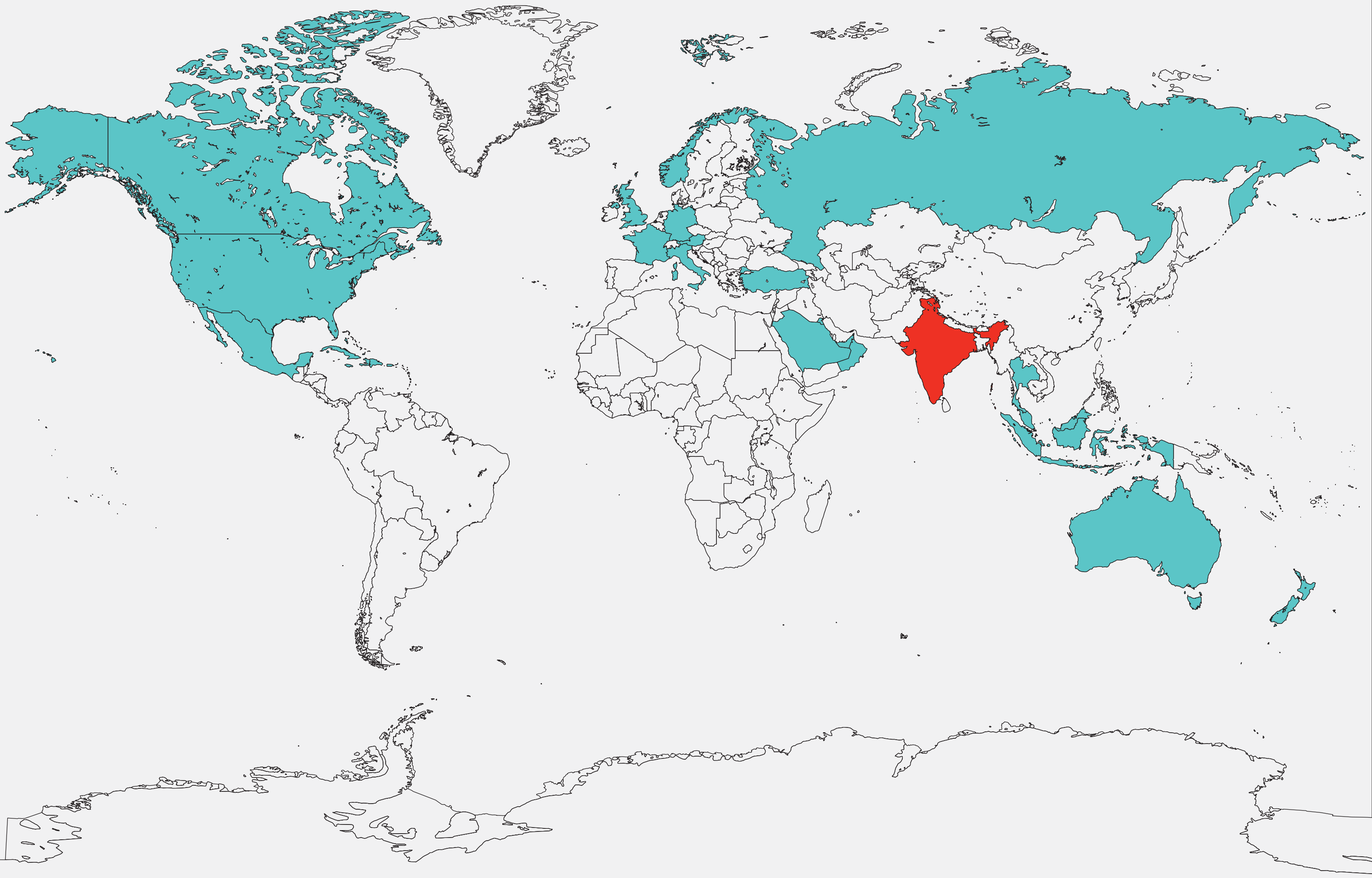
To get another angle on this performance we worked out the following table, where we have simply divided the heat transfer coefficient by the corresponding pressure drop to get the HTPD factor (Heat transfer coefficient per unit of pressure drop). We did this for the three oil viscosities for all the Turbulator models at all the studied flowrates. We have color coded the results so that it is easier to spot the best as well as the trend.

Item	Brine cooled air cooler	Brine cooled air cooler	
Tag	Plain Tube (no turbulator)	(internal flexi turbulator)	
Air flow rate	7700	7700	m3/hr
Air inlet pressure	2	2	kPa
Air inlet temperature	25	25	deg C
Air outlet temperature	6	6	deg C
Heat load	101910	101910	kcal/hr
Brine flow rate	25	25	m3/hr
Brine inlet temperature	-3	-3	deg C
Brine outlet temperature	2	2	deg C
Fouling factor air side	0.002	0.002	hr ft2 deg F/btu
Fouling factor brine side	0.001	0.001	hr ft2 deg F/btu
Face area length	1128	1128	mm
Face area height	915	915	mm
Tube position	horizontal	horizontal	
Tube OD	19.05	19.05	mm
Tube thickness	16	16	BWG
Outside fins	Wire wound	Wire wound	
Tube/ Fin material	SS 304	SS 304	
Fin OD	45	45	mm
Outside heat tr area	2.45	2.45	ft2/ft
Inside turbulator	Nil	19D3	
Tubes/row	alt 18/17	alt 18/17	
Rows/pass	2	6	
Inside reynolds no.	2683	896	
jh factor	7	40	
f factor	0.0004	2.11	
LMTDc	14.2	14.2	deg C
hod linear	42.6	42.6	btu/hr ft deg F
hiod linear	20	77.1	btu/hr ft deg F
Ud linear	13.62	27.4	btu/hr ft deg F
Tube length required	1164.3	636.7	ft
Tube length/row	63.2	63.2	ft
No. of rows reqd	18.4	10.1	
No. of rows provided	20	12	
No. of passes	10	2	
Heat tr area provided ext	3173.4	1856.3	ft2
Air side pressure drop	1.2	0.8	in WC
Brine side pressure drop	0.5	0.4	kg/cm2

Item	Produced water cooler	Produced water cooler	
Tube side flow rate	47354	47354	lbs/hr
Tube side inlet temp.	246	246	deg F
Air flow rate	293602	293602	m3/hr
Air inlet temperature	95	95	deg F
Air inlet pressure	100	100	mm Wc
Air outlet temperature	127.9	127.9	deg F
Tube side outlet temp.	120	120	deg F
Heat load	6248651	6248651	btu/hr
Fouling factor air side	0.002	0.002	hr ft2 deg F/btu
Fouling factor tube side	0.002	0.002	hr ft2 deg F/btu
Face area length	20	20	ft
Face area width	9.524	9.524	ft
Tube position	horizontal	horizontal	
Tube length	20	20	ft
Tube OD	1	1	in
Tube thickness	14	14	BWG
Outside fins	Plain round	Wire wound	
Tube material	Carbon steel	Carbon steel	
Fin material	Aluminium	GI wire	
Fin OD	57.1	51.1	mm
Outside heat tr area	6.16	4.02	ft2/ft
Pitch in rows	67	57	mm
Row pitch	58	44	mm
Tubes/row	alt 43/42	50	
Rows/pass	1	3	
Inside turbulator	Nil	25D3	
Ud linear	28.24	46.06	btu/hr ft deg F
Ud	4.584	11.46	btu/hr ft2 deg F
	22.37	55.9	kcal/hr m2 deg C
Tube length required	4452.1	2619	ft
Tube length/row	838.6	986.6	ft
No. of rows reqd	5.31	2.65	
No. of rows provided	6	3	
No. of passes	6	1	
Heat tr area provided ext	30532.3	11898.7	ft2
	2837.6	1105.8	m2

Tube side fluid	Hot oil	Hot oil	
Shell side fluid	Produced water	Produced water	
Tube side flow rate	19634	19634	lbs/hr
Tube side inlet temp	550	550	degF
Shell side flow rate	47536	47536	m3/hr
Shell side inlet temp	175	175	deg F
Shell side outlet temp	246	246	deg F
Tube side outlet temp	266	266	deg F
Heat load	3573838	3573838	btu/hr
Fouling factor shell side	0.003	0.003	hr ft2 deg F/btu
Fouling factor tube side	0.002	0.002	hr ft2 deg F/btu
Allowable pr drop shell	5	5	psi
Allowable pr drop tube	10	10	psi
Heat exchanger type	BEU	BEU	
Shell ID	19	19	in
Tube type	plain	plain	
Tube OD	1	1	in
Tube thickness	14	14	BWG
Tube material	S32205 Duplex	S32205 Duplex	
Tube pitch	1.25	1.25	in
No of passes	8	6	
No of tubes [U bends]	55	60	
Baffle type	segmental	segmental	
Baffle spacing	6	6	in
Inside turbulator	nil	25D2	
Outside coeff ho	768.3	705.9	btu/hr ft2 deg F
Inside coeff hi	125.8	290.2	btu/hr ft2 deg F
Overall coeff clean Uc	86.52	159.5	btu/hr ft2 deg F
Overall service Ud	58.9	85.7	btu/hr ft2 deg F
	287.4	418.2	kcal/hr m2 deg C
LMTDc	156.5	156.9	deg F
Tube length provided	16	10.0	ft
Heat tr area prov. ext	470.6	325.2	ft2
	43.7	30.2	m2
Overdesign	21.45	22.35	%
Shell side pr drop	1.735	1.224	psi
Tube side pr drop	2.428	9.483	psi

Heat Transfer.
Optimized.
Globally.



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