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COKER RELIABILITY
(Maintenance Strategies)

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(Maintenance Strategies)

Coker Valves – Hot Feed and Vapor Valves.

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    b. hydraulic
2) Remote control of valves.

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Coker Valves

The Delayed Coker unit uses a variety of valves to control the oil flowing through the unit. They vary from gate valves to large blocks of steel called " switching" valves. The valves I will be talking about will be the ones that control the hot feed from the heaters, through the drums and to the Fractionator. These valves are the hot feed switching valve, the hot feed block valves and the vapor valves.

Some of the old Coker units used gate valves to control the hot feed and vapors but the main valve of choice was the 70% open port plug valve. The switching valve has always been the four way style of plug valve. The valve of choice today for most of the new Cokers is the electrically actuated ball valve. This also includes the four way switching valves. Some of the older Cokers have had the old plug valves replaced with the ball valve. This change out also included the switching valves. One of the reasons for the change in the valve style is that there is a large pressure drop across the plug in the old plug valves. The pressure drop across the ball valve is almost zero. Another reason for the change is that the ball valve is much easier to actuate. These valves are now being actuated for safety and ergonomic reasons.

There have been some problems with the electric actuators that open and close these valves. I feel it has to do with the concept of "pull out" torque vs. continuous torque. The torque required for a ball valve is one of the major problem areas. The term "pull out" refers to the amount of torque required to pull a gate out of the valve seats. When this occurs, the torque requirements drop to just about zero. The motors, gears and controls are designed to handle this high torque for only a short period of time. When it comes to the ball valve, this high torque is required for the total time it takes to open or close the valve. This happens because the ball is in constant contact with the seats through out the opening or closing cycle. At times, the torque requirements may be even higher. This happens when there is "foam over" or when a lot of coke fines are carried over with the vapors and get stuck on the ball. It may take a higher torque load to move the ball through one cycle so that the fixed seat can scrap the ball clean. After this one cycle, the torque should drop back down to normal. If the actuator is not designed up front to operate under these conditions, the system can and will fail. This failure can cause a loss of production and, at times, can cause safety concerns.

The vapor valves can cause other actuator problems. When these valves are installed properly (fixed seats looking away from each other) and if the blocking steam pressure that is applied is too high, you can cause the torque requirements that are needed to move the ball to be higher than the actuator can deliver. This will usually cause the actuator to trip off line. This can cause delays again until the steam pressure is reduced and the actuator returned to service by Refinery personnel. This blocking steam needs to be only a few pounds above the operating conditions to effectively block the valves.

We know now that when electric actuators are sized, they need to have some "fat" built into them for the unknown torque requirements and this will add to the over all cost of each valve. I feel that as the vapor valves on Cokers get larger and the cost to actuate them gets higher, the future actuators could and maybe they should be powered by hydraulics. As more and more Cokers are installing automated deheading systems, the hydraulic power needed is already in place. All that would be required is to install some type of hydraulic powered actuator to the valve to complete the system. The problem of not having enough torque would not be an issue any more. There is one company that has had hydraulic powered actuators on some of their vapor valves for a number on years and they have had very few problems. (Sketch attached – A)

Coker Heaters

The Coker heater is one of the more important pieces of equipment in the unit. Its not very pretty but pretty is as pretty does. One of the things that can happen to a Coker heater is that the inside of the tubes starts to build up a layer of coke. This layer gets thick enough that it starts to cause heat transfer problems, coil pressure problems and tube skin temperature problems.

One method to help remove this coke build-up is to do what is called an "on line heater spall". This is a very controlled method where water is injected into one coil at a time. The water causes the coke to start spalling or breaking off of the walls in very small amounts. If this is not controlled and a large enough piece of coke breaks off, the results can be a completely plugged coil. When this method is used properly, the on line running time for the heater can be extended before it has to be brought down for a more detailed cleaning.

One of the more detailed cleaning methods is to "steam\air" decoke the tubes. As you know, this method burns the coke from the tubes and can cause tube damage if not controlled properly. This method does not remove all of the coke from the radiant section and does not remove any coke that may be in the convection section of the heater. We know that the newer Cokers run the temperature in the bottom of the Fractionators a lot higher that they do in the older units. This temperature can run as high as 650^{O}F. At this temperature coke can start forming and will start building up in the convection tubes in the heater.

This leads into the next two methods for cleaning the coke from the tubes. The first method is to remove the tube plugs from one end of the heater and hydro blast the coke out. This method does work but it takes a very long time and does not clean the tube to clean metal. I feel the best method for removing the coke from the tubes is by using a "pig" to fracture the coke first which removes most of the coke from the tube walls. Next a series of "pigs" removes all of the remaining coke from the radiant and convection tubes. The tubes can be cleaned to bare metal. This type of cleaning does not damage the tube wall and does help extend the heater runs between decokes. This is accomplished by not having any remaining coke left where new coke can start to rebuild.

The thermocouples on the heater tubes are an area of concern. If they are not working properly, you have no idea how your heater is performing. You may be firing the heater to a point were you are damaging the tube material. The location of the thermocouple on the tube and the number of thermocouples in each heater cell is very critical for controlling the firing of the heater. If the heater is over-fired, you will shorten the running time between decokes and you can also shorten the total life of the tube material. This over firing can also lead to a tube failure which will cause the heater to be taken out of service for an extended period of time for repairs. The older single fired heaters have the tubes running along the heater walls. Thermocoulpes are usually placed one on each end and one in the middle on ever third tube. The thermocouples are some what protected by the outside walls. The newer double-fired heaters have the tubes running down the center of each cell. The thermocouples are located only on one end of the tubes and are very few in number. This configuration makes it very hard to control the heater firing. You have approximately 250 feet of heater tubing between thermocouples. With this large distance between thermocouples, you really have no way to tell what is happening to the tube skin temperatures much less the oil temperature. I feel that more thermocouples have to be added to the newer heater tubes in such a way that they can be protected from the flames and from being damaged by tube expansion. Also, I think that each thermocouple should have a back up. You do have thermocouples that fail during the run. When this happens, you start to lose control of the heater.

The tube metallurgy for most of the older Coker heaters is the standard 9 chrome materials. There is a relatively new material that I feel is better than the standard 9 chrome for heater tubes. This material is modified 9 chrome (P91 or T91). This material is much stronger than the standard 9 chrome and has some Aluminum in the alloy. This Aluminum in the alloy appears to help keep the coke from sticking to the walls of the heater tube. This can really be seen when you are going through an on line spall. The modified 9 chrome also allows you to operate the heater tubes around 100 degrees hotter without scaling. This can extend the time before a heater must be decoked. (see reference)

The location of the heater outlet thermocouples is an area that needs to either be improved or added to. Most of the Cokers have two thermocouples located in the heater outlet piping. They are used to monitor the temperature of the feed as it leaves the heater. I feel that where these thermowells are located in the discharge piping, they can get a large coke buildup on them which can give a false outlet temperature reading. You can't get to these thermowells to clean them when the heater is in service. To get a more reliable temperature reading, I think a thermowell can be installed in the heater outlet line just inside the piping flange at the feed line to drum flange. This location would allow an operator to clean any coke buildup from the thermo well. There will be a small drop in feed temperature from the heater outlet to this point but that drop can be identified. This would give a more accurate heater outlet temperature indication. (Sketch attached – B)

The combustion air for the old and new style of Coker heaters can be difficult to adjust properly. The older style Coker heaters are natural draft which can present its own set of problems. The draft and O_2 readings for this style of heater are usually taken in the mid section of the heater stack. The accuracy of these readings can be off due to air leaking into the heater box doors and where the heater charge lines go into and out of the heater itself. With the new emissions standards that are in place now and for the more stringent ones they will be coming in the future, these leaks must be sealed as good as possible depending on the overall condition of the heater. The heater may have to be taken out of service in order to solve these problems. When the heater is made tighter, you can create other problems such as having the combustion air in the firebox area so lean that the flames will reach up and impinge on the roof tubes. This condition can cause a very rapid deterioration of the tube material. This can result in a tube failure.

In a forced draft designed heater, one of the problems you may have is the balancing of air flowing through the combustion air ducts. If this distribution gets out of balance, you can also have areas in the firebox that are burning very lean and others that are burning with too much air for proper emission control.

The air preheating equipment is an area of concern. The heater exhaust gas that would normally exit the heater stack is now channeled through the air preheating element. The gas that is used to fire these heaters is made up of a mixture of refinery gases. This gas does have some amount of corrosive material in its make up. When these exhaust gases pass through the preheating element, there is a small amount of this corrosive material that becomes deposited inside the air passages in the element. In time, this can add up to a large amount. The inlet air can have moisture in it and when it passes through the preheating element, a corrosive mixture is left behind. If this deposit is not removed from the element from time to time, the paths through the elements can be damaged or plugged by the deposit buildup.

The heater draft meters are usually located in the mid section of the stacks. The location is also in the same general area where the emission testing is preformed. The O_2 meters are located in the convection section of the older designed heaters. To meet the new emission standards, there should be an individual meter in each cell to properly balance the draft and O_2.

The coil flow regulators can become a problem area when coke becomes entrained in the feed from the Fractionator to the heaters. The coke can get stuck around the control valve stem to a point where it can stop the flow all together or can cause low flow conditions in that particular coil. There are some controllers that have the ability to open more than 100%. This would allow the plug to pass and then would resume controlling again. This type of controller can be set up to open on a signal manually or it can be set up to watch for a pressure differential across it. This differential would signal it to open just long enough for the plug to pass on into the heater coil and resume controlling.

Coke Drums

The coke drum is a large vessel. It can be as large as 30 feet in diameter and 110 feet in height. The nature of the coking process makes this vessel cycle through large temperature swings. This temperature swing is from about 175^{O} F to 850^{O} F. This happens about every 24 hours on the average. On some units, this time can be shorter while on others it can be longer. Because of the high temperature, the vessel must be well insulated not only to help with the process of coking but also to protect the drum shell from the weather elements (rain, wind, cold, etc.). The average drum insulation thickness is only 4 “. This thickness is adequate when the drum is relatively new but as the drum goes through a number of cycles, the insulation becomes less efficient. Any slight damage to the insulation will allow the outside weather elements to penetrate to the hot drum shell. This can cause the shell to sustain damage due to thermal shock at the areas. This damage does not happen with one cycle. It can happen over a period of time if the insulation is not repaired. The thinner insulation also allows the drum to cool down to a lower temperature when the drum is empty. When the drum is at a cooler temperature at the beginning of the cycle, it takes more heat to make the drum ready to receive the hot feed. This is wasted energy. The thicker insulation will protect the drum better and will not let the drum cool down as far as the thin insulations does when the drum is open. If the drum, at the beginning of the cycle, is already at a higher temperature, the amount of heat needed to get the drum ready to receive the hot feed will be less. Over time, this can add up to a large savings in energy. The point to remember is to keep the insulation in good condition. The insulation is the only protection the drum shell has against the outside elements. If rain is allowed to penetrate the insulation, you will not only cause the drum shell to be thermally stressed at that point, you also stand a good chance for your insulation to get water logged. The weight of the water in the insulation can cause the insulation to start to pull away from the drum even more and finally fall completely off.

There are methods to stop the old problem of failing coke drum insulation. As the drum goes through its cycle, it expands about 6 to 8 inches in circumference. This means that the insulation support bands expand the same every cycle. In time, the bands lose their ability to hold the insulation in place. This leads to insulation failure. There is a method where the insulation at each shell ring is trapped between a support system. This prevents the insulation from being able to slide down with time as it can now.

This support system also allows you to have an inspection window at each horizontal weld seam that is two feet in width. These windows are really removable insulation blankets. These blankets can be reused after the welds have been inspected. (Sketch attached- C)

All coke drums will fail with time. How fast they will fail depends on how well they are treated. The drum operates under extreme conditions. It is the nature of this process that puts the coke drum through a very severe operating cycle. The drum will go through a large number of operating cycles before the drum starts showing problems brought on by low cycle thermal fatigue. This may take years to show up but when it does, you need to find out just how bad the problem is. There are methods available where you can inspect the drum between operating cycles with no loss of production. One method uses a laser that is attached to the drill stem. The stem is lowered into the drum at different stopping points. At each stop a complete map of what the drum looks like is generated. A video camera is also attached to the laser system. It can record what the drum wall looks like from the inside. You can zoom-in to look at areas that may have a problem. This system will give you a record of what the drum looks like at that point in time. This information can be used in the future to see how fast the drum may be heading for repairs or replacement. This will give you a history of that drum to work from. If you have a way of removing a band of insulation around the drum at the horizontal weld seams, you can also look at the condition of these weld seams by using shear wave inspection technology. This system can detect any cracks that may be starting to form in the weld seam areas on the inside surface on the drum shell.

By using laser mapping to see what shape the drum shell is in and using the shear wave inspection method to look at weld seams, you can get an idea of the overall condition of the drum.

Now that you know what your drums look like, you may want to add strain gauges and thermocouples to the outer shell so you can see just what you are doing to the drum during operation. You can see just what the drum does when you quench the drum with steam and water. You may want to steam a little longer in order to cool the drum down some before you inject water. We know the drum is damaged when you inject the first few hundred gallons of water. You will be able to see it on the strain gauge. The thermocouples can also tell you how well the drum quenched and if you have any hot spots remaining in the coke bed. You can take all of the information gathered by the laser map, video tape, shear wave info on the weld seams, strain gauge and thermocouple information and put together a program that can extend the life of your coke drums. The thermocouples will also let you look at the drum during warm up. You will be able to see if you have any dead time during the warm up where you are not getting any hotter.

Some Cokers are installing automated deheading systems on the bottom heads. This is an area where maintenance can make or break you. If you don't follow the recommendations of the manufacture on things like head bolt replacement and making sure the head gasket surfaces are clean, you will have leaks. These leaks can lead to down time. When the feed leaks into the moving parts of the deheading system, it can take a long time to remove it and it must be removed before the system will operate properly. Here is where the saying "a little maintenance goes a long way" applies.

The coke drum skirt attachment weld is an area that can cause major problems. The older drum skirts are attached to the drum by a filet weld. This weld is such that you can't see the toe of the weld because it is at the bottom of the bevel. This area can't be back gouged to clean up the first weld at the bottom of the attachment. In time, this area has been a problem with cracks developing at the toe of this weld and progressing into the drum itself. You can see this area only if you remove some of the skirt at this weld. Another way is to use the shear wave inspection method to look at this weld from the inside of the drum. You can see if any cracks are progressing out of the skirt weld and into the shell. (Sketch attached- D)

Coke "Cutting" Equipment

One of the problems you have after you cut the coke from the drums is the coke fines that remain in the water. If these coke fines are not removed from the water, they can cause major erosion problems to the high pressure water piping system. The jet tank should be blown down at a regular schedule. There is also some centrifugal separation equipment that can remove the fines from the water. There have also been stories were the coke fines that are suspended in the water acted like a sand blaster and started removing the clad liner from the drum walls.

These suspended coke fines can also help damage the drilling equipment. This includes any water leaks in the system. The coke fines will help the high pressure water cut any metal surface that it is leaking through very rapidly. This includes the IDECO equipment, any unicouple connection and the cutters on the bottom of the drill stem. Some companies are replacing the unicouple connections on the drill stem with regular pipe flanges because of leaks in the unicouples. The drill stem not being straight is the cause for most of these leaks. This tends to make the stem wobble when turning. This wobbling can loosen the unicouple connection to a point where they start leaking.

The drill stem itself can be made to last longer and resist bending by fabricating them out of a better material such as 4140 heat treated steel. The drill stem can be fabricated to resemble the drill stems that are used to drill for oil. Even the threaded connections can be made by the oil field standards. These are very strong connections and are not prone to leak with age.

The coke fines can also damage the new combination cutting tools being used today. The older style of cutter uses an air signal to switch from the pilot mode to the cutting mode. There are around 23 moving parts in this style of cutter. The fines have a tendency to help these parts wear out faster. The new combinations cutters have a manual system to switch modes. This reduces the amount of parts in the cutter from 23 to about 7. If nothing else, this will help extend the life of the cutter.

Reference for T-91: ASME Sec. II, Part D- Properties

Reference for T-91

TABLE 1A (CONT'D)
SECTION I; SECTION III, CLASS 2 AND 3;* AND SECTION VIII, DIVISION 1
MAXIMUM ALLOWABLE STRESS VALUES S FOR FERROUS MATERIALS
(*See Maximum Temperature Limits for Restrictions on Class)

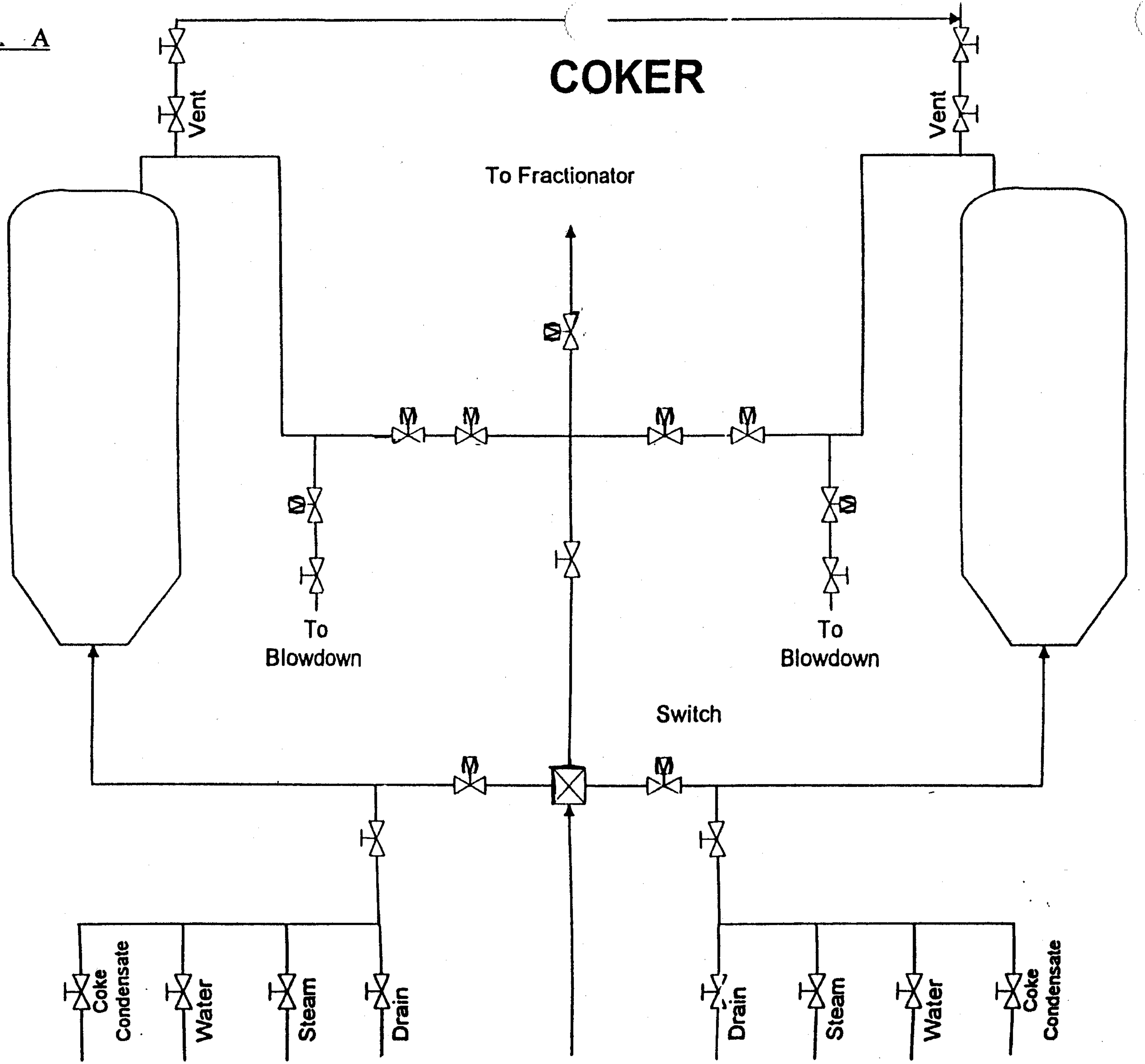
Line No.	Nominal Composition	Product Form	Spec No.	Type/Grade	Alloy Desig./ UNS No.	Class/ Cond./ Temper	Size/ Thickness, in.	P-No.	Line No.	Maximum Allowable Stress, ksi (Multiply by 1000 to Obtain psi), for Metal Temperature, °F, Not Exceeding 950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650
1	9Cr–1Mo	Smls. tube	SA-199	T9	K81590	...	...	5B	1	10.3	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
2	9Cr–1Mo	Smls. tube	SA-213	T9	K81590	...	...	5B	2	10.6	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
3	9Cr–1Mo	Fittings	SA-234	WP9	K90941	...	...	5B	3	10.6	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
4	9Cr–1Mo	Smls. pipe	SA-335	P9	K81590	...	...	5B	4	10.6	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
5	9Cr–1Mo	Forged pipe	SA-369	FP9	K90941	...	...	5B	5	10.6	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
6	9Cr–1Mo	Forgings	SA-182	F9	K90941	...	...	5B	6	11.0	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
7	9Cr–1Mo	Forgings	SA-182	F9	K90941	...	...	5B	7	11.0	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
8	9Cr–1Mo	Forgings	SA-336	F9	K81590	...	...	5B	8	11.0	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
9	9Cr–1Mo	Castings	SA-217	C12	J82090	...	...	5B	9	11.0	7.4	5.0	3.3	2.2	1.5	...	...	...	...	...	...	...	...	...
10	9Cr–1Mo	Castings	SA-217	C12	J82090	...	...	5B	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	9Cr–1Mo	Cast pipe	SA-426	CP9	J82090	...	...	5B	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	9Cr–1Mo–V	Forgings	SA-182	F91	...	...	≤ 3	5B	12	15.5	14.3	12.9	10.3	7.0	4.3	...	...	...	...	...	...	...	...	...
13	9Cr–1Mo–V	Forgings	SA-182	F91	...	...	> 3	5B	13	15.5	14.3	12.9	9.6	7.0	4.3	...	...	...	...	...	...	...	...	...
14	9Cr–1Mo–V	Smls. tube	SA-213	T91	...	...	≤ 3	5B	14	15.5	14.3	12.9	10.3	7.0	4.3	...	...	...	...	...	...	...	...	...

A97

TABLE 1
CHEMICAL REQUIREMENTS FOR FERRITIC STEEL

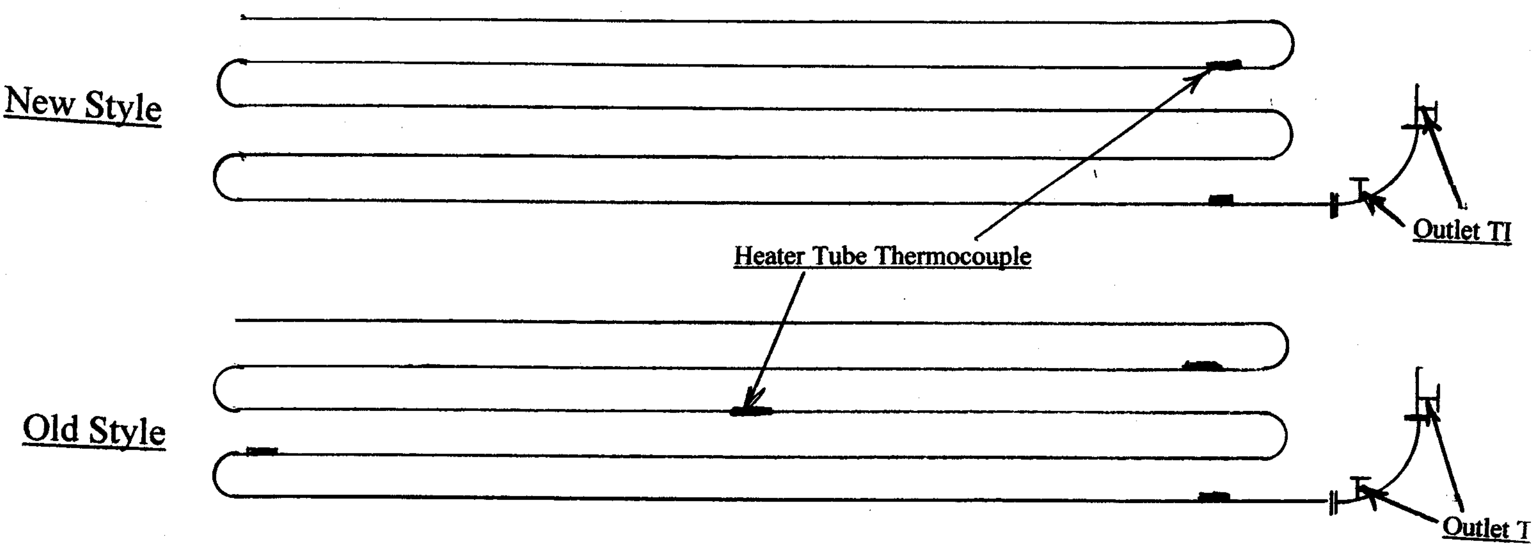
Grade	Composition, % Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium	Molybdenum	Titanium	Vanadium, min	Other Elements
T2 [Note (3)]	0.10–0.20	0.30–0.61	0.025	0.025	0.10–0.30	0.50–0.81	0.44–0.65	...	...	
T5	0.15 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	...	...	
T5b	0.15 max	0.30–0.60	0.025	0.025	1.00–2.00	4.00–6.00	0.45 –0.65	...	...	
T5c	0.12 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	[Note (1)]	...	
T9	0.15 max	0.30–0.60	0.025	0.025	0.25–1.00	8.00–10.00	0.90–1.10	...	...	
T11	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50–1.00	1.00–1.50	0.44 –0.65	...	...	
T12 [Note (3)]	0.05 min–0.15 max	0.30–0.61	0.025	0.025	0.50 max	0.80–1.25	0.44–0.65	...	...	
T17	0.15–0.25	0.30–0.61	0.025	0.025	0.15–0.35	0.80–1.25	...	...	0.15	
T21	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50 max	2.65–3.35	0.80–1.06	...	...	
T22	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50 max	1.90–2.60	0.87–1.13	...	...	
T91	0.08–0.12	0.30–0.60	0.020	0.010	0.20–0.50	8.00–9.50	0.85–1.05	...	0.18–0.25	Cb 0.06–0.1 N 0.030–0.070 Ni 0.40 max Al 0.04 max

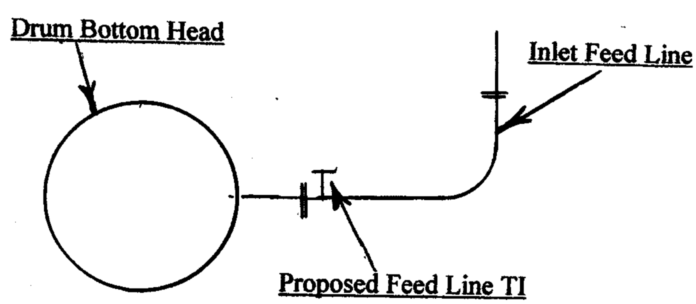
Sketch A



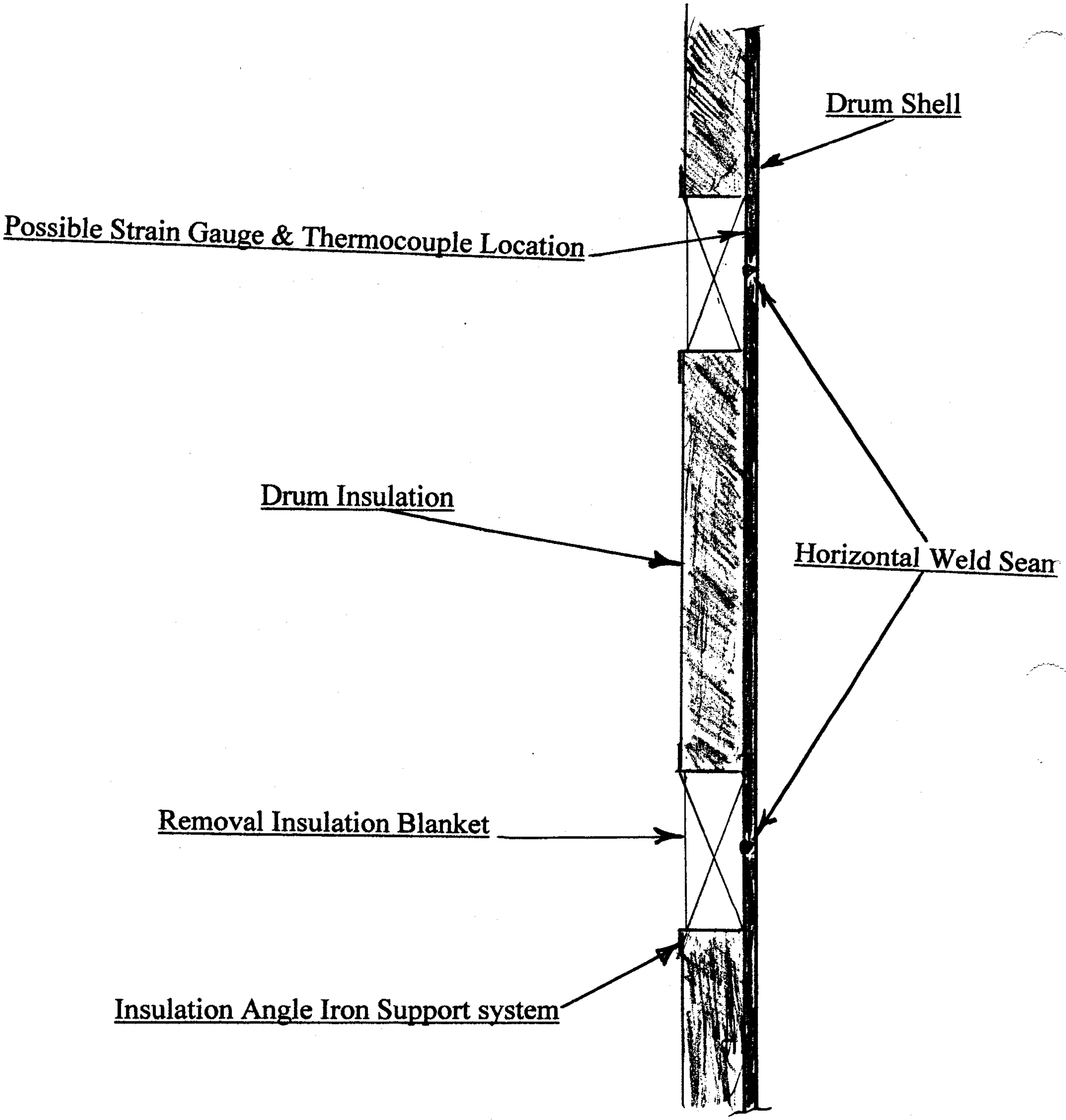
COKER
Vent
Vent
To Fractionator
M
M
M
M
M
M
M
M
M
To Blowdown
To Blowdown
Switch
Coke Condensate
Water
Steam
Drain
Drain
Steam
Water
Coke Condensate

Sketch – B


New Style
Outlet TI
Heater Tube Thermocouple
Old Style
Outlet T


Drum Bottom Head
Inlet Feed Line
Proposed Feed Line TI

Sketch – C


Drum Shell
Possible Strain Gauge & Thermocouple Location
Drum Insulation
Horizontal Weld Sean
Removal Insulation Blanket
Insulation Angle Iron Support system

Sketch - D