Challenging Encounters In Trouble Shooting Of Refrigeration Systems

If you are involved in manufacture & design of field engineered process plants and Air Conditioning systems for more than 5 decades, you are bound to come across many situations, which appear to be baffling even to the most experienced engineers.

Many times, once the solution becomes evident, it appears to be too simple, but till such time many man-hours are spent & expenses incurred before you find a solution that looks too simple, once the problem get resolved.

More than 99% problems can be solved with logical thinking, systematic analytical approach and using step-by-step elimination process, to arrive at correct diagnosis & then to eliminate the root cause, rather than working on short-term solutions.

The problems encountered can be classified under various categories.

1. Equipment design/manufacturing related issues
2. System engineering & component design errors
3. Lack of communication/clarity between supplier/buyer
4. Over confidence, or insistence by consultant and buyer
5. Not Adapting technology to suit local conditions
6. Lack of proper knowledge in installation/ piping practices of erection staff
7. Lack of understanding on proper working of system components
8. Ignorance of relevant clauses from applicable codes/standards
9. Not following drawings and using one’s own judgement

Since 1966, I have been associated with more than 700 engineered refrigeration/air conditioning systems for applications ranging from $–80^0$C to comfort A/C projects involving different refrigerants.

I have also, the experience in successfully, introducing and implementing technologies like semi hermetic compressors, centrifugal & screw compressors, bus air conditioning and truck refrigeration systems, flake ice machines, all for the first time in the country & sharing some of the experiences encountered during this span of 50 years may help others if they come across similar instances.

I would also like to mention that since the period elapsed from the occurrence of event is considerable, it would be difficult to give all the correct information, specifications, drawings or any other statistics of each event, however, I would try to rely on my memory and touch upon the significant aspect of such event only to highlight the issue.

EQUIPMENT DESIGN & MANUFACTURING RELATED ISSUES

Normally if the manufacturer strictly follows drawings, specifications and methods given by his principals/collaborators, chances of errors are few and even if they occur, they can be easily identified and rectified.

As manufacturers of open type reciprocating compressors, we used these machines for various applications ranging form low temperature to comfort applications.

After installing more than 1000 of these compressors for such varied applications, we started facing typical problem of suction valve plate chattering and breaking, only on applications involving comfort air conditioning applications using R-22 refrigerant. The same compressors working on Ammonia installations did not face this problem, and we could not identify the reason for such premature failures. After exploring all possible avenues such as checking and rechecking drawings, inspecting components thoroughly, we finally decided to approach our principals in Holland, expecting a usual answer to recheck all over again, the areas we had already covered.

To our surprise, we immediately got a response stating that they had also encountered similar problem and asked us to increase the tolerance between stroke limiter diameter and the valve ring by few microns by reducing stroke limiter diameter. Once we did this change, the problem got resolved.

Now the interesting point is how increasing this tolerance helps in solving problem with R-22 comfort Air Conditioning applications?

On subsequent interaction with principals, it was revealed that at higher suction pressures, the density of R-22 being very high, and due to uneven pressure exerted by small coil springs the inner rim of valve plate was hammering against stroke limiter diameter, leading to failure. As soon as the suction pressure reduced, the problem used to disappear as the gas density reduces and the valve plate rests firmly in the recess provided since the suction pressure is higher than the cylinder pressure. On piston’s upward stroke as the cylinder pressure rises over suction pressure, the springs force the valve plate on to its seat.

R-22 vapour density at 40^0F is 1.524 lb/ft^3, where as for Ammonia it is only 0.2523 lb/ft^3 at the same temperature.

Subsequently, manufacturer changed the design and instead of many small springs, replaced with two much stronger sinusoidal springs.

I am sure all of you would agree with me that, this problem was beyond the imagination of our engineers and could only be resolved with such assistance for principles.

The important point to be noted is that the property of refrigerant was inducing this problem and had nothing to do with manufacturing accuracies.

SYSTEM ENGINEERING COMPONENT DESIGN

As all of us know, the condenser heat rejection is higher than the evaporator load. For air conditioning application it is nearly 1.2 to 1.25 times as a thumb rule. It is however always a good practice to actually calculate the same. Normally the safety factor is taken into account and actual operating conditions, which as a rule are always less than design load conditions, especially in comfort air conditioning applications. The problem of missing this aspect of correctly sizing the condenser may remain unexposed, however, on low temperature, process plants, not taking in to account heat of compression for condenser heat rejection can lead to serious problems.

In one of the major installations using 8 nos. -25^0 C brine chilling packages, the system designer had selected condensers suitable for evaporator load. As the compressors employed were unibuilt two stage design, they had to start with one cylinder of high stage getting loaded first, till such time the temperature dropped to such an extend, when low stage cylinder could be switched on.

Due to obvious error, in selecting condenser, to cater for correct heat rejection, the plant could never be started or run continuously without tripping on H.P. cut out.

There was no place also in the plant room to install additional condensers for each package or to replace existing condensers with bigger size. Thus, the project commissioning faced severe problems and the contract finally ended with litigations, leading to huge losses for both client as well as suppliers besides bad publicity.

On a similar smaller plant, using one package, the problem could be resolved by supplying one additional condenser, so that two condensers shared initial cool down load, till temperatures dropped to reasonable level.

To high light this issue, if we look at the typical ratings of two stage compressors, KC 21 compressor with R-22 refrigerant, when starts initially from ambient conditions with one HP cylinder operating, has a capacity of 45 Tons at $+40^0$C/$+10^0$C, where as when it operates as two stage compressor with $+40^0$C/-30^0C conditions, it has a capacity of 18 tons.

One can appreciate, if a condenser is designed for 18 Tons heat rejection, how one can start and operate the plant automatically, without tripping on HP.

Similar precaution needs to be taken while selecting the electric motor of adequate capacity to take care of initial starting and cool down load conditions as well, for a low temperature application.
A selection of brine tank capacity also needs careful consideration, if one is not able to load compressor to full capacity at start up, then to cool the stored quantity of brine in the tank from ambient temperature could take a very long time which customer would not be willing to accept.

LACK OF PROPER COMMUNICATION

A chemical plant operating with Ethylene Glycol brine at -20^0C brine was installed in Mumbai, using Ammonia flooded chillers.

Similar plants were earlier executed and were working well. The sequence of events in this particular instance was as under.

The project commissioning was delayed due to certain reasons and the completion of refrigeration plant and the main chemical plant were ready for start up simultaneously. There was no time available to test the refrigeration plant in advance and keep it ready before chemical plant could be started. The German engineers, responsible for process design were present & our most experienced erection crew was also at hand. We were quiet confidant that the plant would work well without any hitch. When the plant trials commenced, the charging of gas in the refrigeration unit was done simultaneously. With in short span, instead of expecting smooth operation resulting in brine temperature drop, liquid refrigerant started coming to compressor, and the suction pressure was not dropping. Our commissioning crew did normal checks such as brine pump operation, all line valves in open position, liquid level controller functioning etc. Every thing appeared to be normal. The German chemical engineers thought that, the chiller design is faulty and adequate area has not been provided. Our site engineers were of the opinion that the liquid level controller was not at the correct height and needs to be lowered. As there was no consensus, an urgent call came to me at 4.00 PM to rush to site immediately as all the engineers were waiting at the plant. In those days it was not so easy to reach Mumbai, and with great difficulty, I could reach site at night by 10.00PM.

Immediately, every one cornered me and started telling me their analysis and theory as to what is wrong with the system design. I requested them to restart the plant, and as expected, liquid started coming to compressor within short time, without expected reduction in brine temperature. I then tried to throttle the suction valve manually, to prevent liquid stroke, but the plant had to be stopped. I could not understand, why this is happening, when all other parameters looked normal, and I had confidence in my design of heat exchangers as well as in piping layout. It was evident that not much heat transfer in chiller is taking place.

I then requested the client for the design specifications. The supply and charging of Ethylene Glycol brine was part of client's responsibility. The recommended specifications, called for brine of 45% concentration. I then asked the client as to the source of procurement of brine. Client searched for the record and showed me the purchase order placed by him. It was on a reputed supplier, and therefore question of quality of brine was beyond suspicion. The scrutiny of the order revealed that he had placed order for 45% concentration of brine as a requirement. Doubting something wrong, I asked, who has prepared the brine mixture and ensured required concentration? To my surprise, client replied that there was no question of preparing brine concentration at their end and they had charged the system with the supply as received from the manufacturer, assuming that the manufacturer has taken care of necessary concentration as specified in the order.

In short, client had charged 100% Ethylene Glycol solution, in the system directly from the drums received from supplier.

Refrigeration designers do not need further explanation as to why the plant was misbehaving. With 100% concentration, obviously with high viscosity, there was hardly any heat transfer taking place. The viscosity of E.G. at -5^0F is 18.00 cSt, with 45% concentration, where as it increases dramatically

180 cSt (to 10 times) if the solution concentration is 100%. Similarly, the thermal conductivity reduces from 0.26 to 0.18 when solution concentration increases from 45% to 100%, (44% reduction). Also, the specific heat of the mixture drops from 0.72 to 0.52 (38% reduction).

I then requested to restart plant and started filling water in the tanks with the hoses and simultaneously removing excess quantity. As the pure Glycol started getting diluted with water, the brine temperature started dropping and finally at 4 0'Clock in the morning we got desired results when right concentration was achieved, without any liquid coming to the compressor.

It can be thus seen, that this problem was due to taking certain things for granted leading to unexpected situations. Clarity on requirements, what is expected from each agency and dialogue with all concerned people could have avoided such situation.

OVER CONFIDENCE OF CONSULTANTS

ASHRAE Refrigeration handbook chapter on refrigeration for chemical industry summarizes this beautifully. Chemical engineers expect refrigeration as any other utility, like steam or air or water and feel that refrigeration will be available in the similar manner when the tap on the water valve is opened.

They, very rarely, are willing to share process side data and designs and indicate it is confidential.

We, as refrigeration engineers know, that our systems work in conjunction with chemical processes and knowledge on either side is essential for trouble free design and operation of entire plant.

At one of the plants designed by a leading consulting firm from USA, we were associated to provide refrigeration. The plant was supposed to manufacture CFC refrigerants, and therefore used R-22 for refrigeration plant as well. The battery limit conditions specified quantity of R-22 refrigerant in the liquid form to be made available at a particular pressure and temperature. This liquid refrigerant was then used in various process heat exchangers using refrigerant on the shell side and fluid on the tube side the heat exchangers were located at considerable height on third floor, where as the refrigeration plant was in the basement. In order to protect compressors, there was a big size knock out drum (accumulator).

When the plant was commissioned, it was found that the liquid was getting filled up in the drum and then subsequently entering the compressor suction header. In short accumulator was only delaying liquid stroke. Obviously, the system fault existed.

The consultants and the client were reluctant to take us in confidence and show the process side stating that it is confidential information. However, on urging them finally they took us to the plant. All the liquid level controllers were checked for proper operation. These were pneumatically operated instruments with control valve and all related controls and indicators/alarms like high/low level etc. The entire process was monitored from remote location from the central control room

It was obvious that as the liquid was boiling, the suction drag force due to powerful compressor suction was picking the liquid droplets to suction. Once the droplets entered suction they had to travel only in the direction towards compressor suction and could not come back.

The process heat exchangers were kettle type design, regularly used by chemical engineers and not the flooded design similar to what refrigeration engineer normally provides.

We normally provide a shell and tube flooded cooler with liquid level controlled at 75% to 80% height and in addition to this we provide a surge drum on top of the cooler, so that in case the liquid droplets are dragged upwards, due to reduction in velocity to approx. 75 to 100 fpm, the heavy liquid droplets fall back in the vessel instead continuing its journey towards compressor.

An extremely good article on the subject on design of flooded coolers and how to avoid liquid migration to compressors is written by a well-known authority in refrigeration, Mr. W. F. Stoecker and has appeared in Heating, piping and Air Conditioning journal- December 1960 issue.

We discussed this issue at length. and Initially consultants were reluctant to agree to the fact that there was very less space available on top of the tube bundle to effectively separate liquid and vapour zone and in spite of level controllers, due to vigorous boiling of refrigerant, velocities being high, and no provision of liquid separator on top of the vessel, liquid carry over to compressors was taking place.

After 3 days discussions, although consultants were reluctant, and client had no other alternative suggestions coming forward from consultants, agreed to modify process heat exchangers as per our recommendations.

The plant was shut down for 5 weeks and all process heat exchangers were modified & provided with surge drum on top to effectively separate vapour and liquid.

After the plant was recommissioned, every thing worked well.

Finally, consultants agreed that they should have taken us in confidence earlier, which could have avoided such costly repairs and wastage of client's valuable time.

INCORRECT COMPONENT SELECTION:

Recently a project was undertaken by me to modify existing system and use ammonia gravity cooling system for cold storage designed to store fish at -20^{0}C.It was single room cold storage with single air cooler. The air cooler was from reputed manufacturer and with full confidence we started the plant as it was one of the simple system designs. As soon as we switched on the system, the ammonia liquid would fill the air cooler as it was bottom entry cooler but the liquid would also go to the stand pipe, fill it up and then liquid would fill up the accumulator and from accumulator to compressor.

We tried every possible solution including increasing the diameter of accumulator, raising the height of accumulator more than necessary to avoid liquid coming to compressor, but all efforts did not give any improvement.

I finally decided to take help of a known expert from IIAR USA and he asked me to check several things such as piping diameter, stand pipe diameter, slope from accumulator to compressor etc. I gave him all the information, forwarded him my piping diagram and vessel drawing as also air cooler drawings. The final answer given by him was we were using commercial air coolers and not industrial coolers. After receiving such reply, I decided that they are not able to provide correct diagnosis. Finally, what we did is start the air cooler, fill it up, start the fan and switch it off immediately before liquid fills up the accumulator to the top level. With such operation the temperature dropped by 0.5 deg. C inside the room. I then continued this process several times lowering temperature every time by 0.5 deg. C. Continuing this operation of switching fan on/off for 75 to 80 times the temperature of the room dropped to -15 deg. C and then the air cooler started functioning properly and the temperature finally reached designed value of -20 deg. C.

When we forwarded these details to another refrigeration expert from USA, he then commented all engineers always worry in such cases as why liquid is not entering air cooler and instead filling the accumulator.

He indicated that the outlet pipe from air cooler was too small and whatever liquid was getting evaporated and getting converted in gas, the connection was not big enough for the gas to escape and was thus building the back pressure which was forcing the liquid in to the accumulator through stand pipe.

Very important statement was made by him that in such case always look for why the gas is not escaping from the air cooler instead why liquid is not entering the cooler. Once the gas finds the escape route easily, the liquid would automatically enter due to gravity.

In spite of my experience of over 4 decades I experienced this type of puzzling problem for the first time.

The lesson to remember is size the outlet pipe of air cooler to meet initial high refrigeration load when the room is warm. We normally select cooler assuming that the room is going to store frozen product and the product frozen elsewhere would enter the cold room. The refrigeration load is therefore small and this leads to small size coolers and naturally the connections are also small. It is therefore necessary to provide adequately bigger outlet connection so that the gas formed from initial vigorous boiling of refrigerant would escape easily and liquid would then enter automatically by gravity.

UNDERSTANDING RELEVANT CODES & STANDARDS

We were lucky to get associated with India's largest Petrochemical plant at Baroda. The total plant capacity was 2200 Tons, using Ammonia refrigeration and the temperatures up to minus 27.5^{0}C. The project being executed under the consultancy of the largest public-sector consultancy engineers, and was under strict requirements of all relevant international codes and practices.

The material requirements were also to international standards and in those days (1975), it was difficult to get raw material to required codes, hence client supplied the material.

The heat exchangers were designed to TEMA- B standard and construction was as per ASME SEC VIII Div. 1. The drawings of each heat exchanger were routed through various groups of consultancy engineers, such as thermal and, process design, maintenance group, strength checking and to ensure that the design strictly meets the code requirements. After many interactions and incorporating requirements of various groups, the drawings were finally approved and the fabrication of heat exchangers was carried out under the strict supervision of inspecting engineers. The heat exchangers were large, compared to normal refrigeration condensers/chillers which one is used to, and the sizes were 38" dia. By 20' long using 670 tubes of 1.25" diameter and weighing 18 Tons each.

After the heat exchangers were manufactured and were stamped by inspection engineers, we were making arrangements for organizing dispatch.

Suddenly on one fine morning we received a fax from the chief engineer of the consulting firm that all the low temperature vessels and heat exchangers stand rejected, since we have not carried out Charpy impact test on raw material before using it for fabrication and vessels are likely to fail in operation.

As per ASME code for use on low temperature applications, it is mandatory to carry out this test. This requirement had also escaped the attention of their inspecting engineers, however we being the suppliers, the consultants squarely put the blame on us & said that the ultimate responsibility rested with us.

This communication was bolt from the blue, and all our efforts in manufacturing over two years came to naught, leading to huge financial loss to the company if we had to start all over again.

In desperation I approached ASME committee in USA to find whether any concessions to such requirements is available for refrigeration duty, since we had never done such testing earlier in any of our low temperature plants and all of them were working well for long periods without any damage.

To our great relief we received the letter stating that as per UCS-66(c)(1), no impact test is required on any material for use at temperatures of –20^{0}F(-28.9^{0}C) and above, if the pressures and temperatures do not occur simultaneously.

The code states that materials subjected to temperatures, below minus 20^{0}F, except as under shall be impact tested as required by Para UG-84 of Section VIII Div 1 of the ASME Boiler and Pressure Vessel Code, and will have charpy impact value at the operating temperature of not less than 15 ft lb using keyhole notch.

EXCEPTION: -

Carbon, low alloy and high alloy steels (but not austenitic ductile iron) may be used at low temperatures not lower than –50^{0}F (-46^{0}C$^)$ without impact testing if the operating pressure will not be more than 25 per cent of the maximum design pressure at ambient temperature

The reason being, in refrigeration applications, pressures and temperatures do not occur simultaneously, unlike chemical process heat exchangers. In other words when the vessel is operating at low temperature, the corresponding pressure is very less, and since the vessel has been designed for much higher pressures, it is always safe for operation at low temperatures.

The ASME volumes are large and to read and master all the information is not a regular requirement of refrigeration engineers, but we should learn such clauses, which are relevant to our industry, to avoid any such happenings. The consultants and chemical engineers are experts in heat exchanger designs, but are also not aware many times of special requirements of refrigeration industry.

The importance of understanding each other's requirements has been highlighted nicely in ASHRAE Refrigeration volume as stated earlier.

It is therefore essential that both the parties are fully aware of required codes and practices, to avoid such misunderstandings.

If we would have accepted consultant's rejection, one can imagine what would have been the outcome.

After showing the relevant letter received from ASME, client finally accepted the vessels.

TECHNOLOGY ADAPTATION TO SUIT LOCAL CONDITIONS.

Our company's strength was in designing refrigeration plants for low temperature applications.

One of the early plants involved selection of two stage Ammonia compressors for a brine chilling plant-supplying brine at -28^{0}C to process. The installation was in Mumbai for one of the pesticides company using German Technology.

The chief engineer was also German engineer posted by the principals.

The plant was commissioned and worked well. All handing over formalities were completed to everyone's satisfaction.

After a period of one week we received a call from client, indicating that there is abnormal wear out on cylinder liners. We promptly deputed our service staff and, on their suggestion, replaced a batch of 12 liners for one compressor. We, then started investigating why such premature wear out are taking place.

There was no liquid carry over and thereby affecting lubrication. We also checked cylinder alignments to confirm that the axis for each cylinder was true as per drawing, and hence possibility of wear out due to incorrect manufacturing/fabrication did not exist.

Having completed this study, we thought that probably, the particular batch of liners might be defective and not having material composition as per specifications.

After replacing the cylinder liners, and supplying correct liners after through inspection, we were reasonably sure that the problem would disappear.

This did not happen and we again got call after few days indicating the repetition of the same phenomena.

The German chief engineer thought our liner material is not correct and we either change the material or do some hard chrome plating or change the design of piston rings etc.

He also suggested that we should seek assistance from our sister concerns who had immense experience in manufacturing reciprocating machines, particularly diesel engines.

We did not want to take such route since in all other installations the compressors were working well without such premature liner wear out.

Meanwhile we continued replacing liners at regular intervals, costing enormous expenses to company.

The compressors were built as per collaborators design and client insisted that we call their expert since they also knew our collaborators well, as they were using similar compressors in Germany.

Accordingly, we requisitioned services of our principal's expert, and when we took him to site, every one was eagerly awaiting to find out what is his diagnosis and remedial suggestions. We took him around the plant along with German chief engineer.

We then assembled in the conference room to eagerly hear from him. He indicated to client that he has found the solution but would convey the same next day after he holds the discussions with our team.

On reaching Pune he informed us that the problem was not serious and suggested that we change currently used oil Zerice R 44 (43/44 cSt at 40^0C) with a higher viscosity grade oil and confidently said that the problem would be resolved. When we told him that we are using oil as per collaborators recommendations, he then clarified that the recommendations are basically for European countries with cold or moderate climatic conditions. In India for higher ambient conditions, the chart needs to be modified. Normally it would be all right for any other application but with Ammonia refrigerant and with two-stage application for such extreme low temperature use, the compressor discharge temperatures are very high and affect lubricating properties of oil adversely. It is therefore suggested that thicker grade oil should be used.

When we carried out this change, the problem of liner wear out disappeared. We then changed our oil recommendation chart incorporating Indian Oil Servofriz-68 or Seetul 68 from HP which has a viscosity of 68 cSt at 40^0C for all users resulting in improved performance for all installations and reduced maintenance costs.

The lesson to be learned is many technologies need to incorporate requirements to suit local conditions instead blindly following foreign technologies.

Similar problem was faced in early stages, when we started manufacturing hermetic compressors for room air conditioners under the license from a world reputed manufacturer. The failure rate on electric motors was very high, nearly 20%. The motors were manufactured exactly as per specifications of collaborators. The problem when analyzed, indicated that the voltage and frequency variation for which the original design of motor was not at all suitable for erratic power supply in India where voltage and frequency variation swings were much beyond the prescribed limits of collaborators, and thus leading to high failure rates. We had to redesign the motors to suit local electric supply conditions, after which the failure rate came down to acceptable standards.

PROPER UNDERSTANDING OF WORKING OF COMPONENT

It is important for suppliers of components as well to understand the function and end use of the product. It may lead to unexpected problems in some cases.

We were manufacturing flake ice machines using Ammonia as well as R-22 refrigerants. The icemaker used flooded design, in which low temperature refrigerant was filling up the double walled cavity in the cylinder. The water sprayed on the inner wall was getting converted into ice.

The fabrication of icemaker drum was subcontracted and machining process was in house operation. The liquid refrigerant to ice maker is fed with the normal arrangement of hand expansion valve and solenoid valve combination controlling liquid level in a accumulator, connected to icemaker with the liquid and gas equalizing connections.

We installed one such icemaker in a chemical/dyestuff plant in Mumbai. No sooner the ice plant was started, we observed that the liquid is directly filling the surge vessel and entering the compressor without producing ice.

We then carried normal checks, such as operation of float switch, ensuring all equalizing valves are open etc. Our site engineer thought the liquid level is too high and we then lowered the drum and reduced the height, with out any success. We then opened the system to find whether any plastic cap is blocking the liquid flow to the icemaker drum. Many times, erection staff forgets to remove plastic caps and join the piping in a hurry. When the system is put on vacuum, the caps may get sucked in the line and thus blocking flow path. On this installation we did not find any such problem.

Finally, when no solution was in sight, we decided to bring the icemaker to factory and decide to cut open the cylinder to find what is blocking the refrigerant flow.

To our horror, we found that the fabricator had provided a complete round strengthening ring above the refrigerant liquid inlet connection, instead providing just the four small joining pieces to hold the cylinder inner and outer wall as shown in the drawings. This resulted in liquid not entering the icemaker at all, but was directly going to accumulator vessel and finally entering the compressor.

When we asked the fabricator, who incidentally was not our regular supplier, why he had done so, he indicated that since he was doing the job for first time he wanted to do a good job and thus thought of strengthening the design further by providing complete support instead of few small ribs. If he had known the application and the operation of icemaker the situation would not have arisen.

The best intensions, with out knowledge of system operation could thus lead to puzzling problems.

There are endless such experiences, however narrating few of them within the time allotted was possible. All of you present today must have faced many such varied situations in your career & I am sure you would appreciate what we have discussed today.

CUSTOMER IGNORANCE:

In one of the fish freezing plants at Porbandar, I was asked to design the refrigeration system. The customer had seen similar plants installed in the area and insisted that I should use GI pipes for refrigeration ammonia lines. His argument was, GI pipes are thicker than A179 seamless pipes and also do not rust, whereas A179 seamless pipes would rust because of atmospheric conditions as they were near the sea shore. He did not consider that the GI pipes are also having GI coating from inside and once ammonia would come in contact, the Galvanization would be removed and would be harmful to the components of refrigeration system such as valves, controls, compressors, and would choke the strainers. It took lot of convincing and he wanted to show me the standards where it is written that GI pipes cannot be used for refrigeration.

An ammonia standard for Indian condition is therefore us essential to improve the overall standard of installation practices.

NOT FOLLOWING DRAWINGS AND USING ONE'S OWN JUDGEMENT-BY ERECTION STAFF:

1. Location of evaporative condenser w.r.t. receiver

Recently I was asked to design a plant using IQF for sweet corn freezing at Nasik. The capacity of freezing was large and required large capacity 1500kW evaporative condenser. The weight of empty condenser was also 9 Ton. It is essential that when any type of evaporative condenser is installed, it's liquid outlet should be nearly 1.5m or 2m above the receiver inlet, otherwise the liquid would not get drained in the receiver and condenser coil would start accumulating condensed liquid. In this particular instance, although the drawing showed this information and had indicated the minimum distance to be kept between condenser outlet and receiver inlet, the customer and his erection engineer did not follow the drawing and kept receiver next to condenser at the same level on terrace. During site inspection before commissioning I noticed this and inquired why this has been done and why condenser has not been kept on elevated platform to maintain required distance. The reason given was the condenser was very heavy and they did not get a crane with long reach to lift the condenser and hence kept directly on the terrace. It was difficult to change now the set up and the screw compressor package was using thermosyphon oil cooler which also required that there has to be a minimum height difference between main receiver and thermosyphon oil cooler.

It was very difficult situation and only alternative was to lift the evaporative condenser or think of some other odd alternative. Finally, I decided to hang the receiver below the slab by making the brackets to take weight of fully filled ammonia receiver. We had to drill holes in the slab to fix the brackets and take liquid pipe inside. This was the only solution possible without re-erecting the entire plant. The problem was resolved in this manner and the plant is now working satisfactorily for last 3 years.

DIFFICULT SITUATIONS AND EASY SOLUTIONS:

During one of my visits to Ahmadabad, where I conducted the workshop on design of cold storages, one customer insisted that I visit his plant as he is having a problem and no one is able to give some solution.
I visited his plant after my presentation was over. The plant was ammonia chilled water plant using 9-cylinder reciprocating compressor and shell and tube flooded chiller with surge drum mounted on top. The complaint was when he runs the plant with 6 cylinders of the compressor the plant runs well however when he switches it to full load, with 9 cylinders operating the liquid starts coming to compressor. Every one is asking him to change the surge drum with a bigger size and this is a complicated solution as he would be required to also provide bigger out let from chiller to surge drum needing cutting the shell.

If one knows the theory part, the solution was easy. It should be remembered that when the liquid is boiling in the evaporator, there are two forces acting on the liquid droplets that are trying to escape from the boiling surface-one is the gravitational force trying to pull the liquid droplet down and other is the powerful compressor suction. Whichever force is more the liquid droplet would travel in that direction.

Obviously, in this case the suction pulling force by compressor when running on 9 cylinders was more than gravitational force and the liquid droplet was entering suction line and thereafter travelling to compressor. I suggested him to provide two outlets on top of the chiller joining the surge drum of bigger diameter and. With this change, the velocity of suction was reduced to nearly half and the liquid stopped coming to compressor as the gravitational force on liquid droplet exceeded than the compressor drag force and the liquid droplets fell back to chiller. If one sees the drawings of chiller surge drum combination of reputed manufacturers, instead of increasing the diameter of surge drum, they provide as many as 4 pipes on top of chiller joining the surge drum and thus this becomes a more economical solution. The velocity should be kept around 75fpm in these pipes as a general thumb rule to avoid liquid droplets entering the compressor.

DIFFICULT SITUATIONS AND DIFFICULT SOLUTIONS:

Our company used to do many projects for Hindustan Shipyard for cargo shipment for the export. The ship would carry frozen cargo from India and on return journey bring back fresh cargo. The containers ships were this having cargo holds and piping arrangement on two stage compressors so that they would run as two-stage on outbound journey and by closing some and opening some valves would be converted to single stage compressor for bring in fresh cargo from abroad.

One ship for passenger liner build for shipping corporation was also air conditioned using our compressors. A six-cylinder compressor with 150 HP motor was used for air conditioning.

One day we received call from Mumbai that the compressor is having problem and needs to be reappeared. Fortunately, our collaborators expert was in Pune and we therefore rushed to Mumbai along with my boss and the expert. It was monsoon and the heavy rain. Sea was very rough. The ship was parked in the sea and we had to go to the ship in a small boat. Myself and the collaborator’s expert went to ship in a rough weather and rain holding the umbrella, which was only mental satisfaction and did not prevent us from getting fully drenched.

When we went in to the plant room where the air condition plant was kept we found to our horror that the crankcase was broken and the crankshaft was jutting out from the crankcase. It was impossible to repair the compressor on the ship and it was essential to bring the same back to factory.

Perhaps everyone may be aware that the ships main engine is high and was more than 30000Hp capacity and was occupying entire center portion of the ship and the machine room was on one side. The engine was lowered lastly after all the utilities were in position and there was no enough space between engine and machine room to take out the compressor unless main engine is lifted or dismantled. This was obviously not possible. The only alternative was to cut the ship from outside and remove the compressor. Finally the shipping corporation agreed to this and we had to cut open brand new ship steel from out side , remove compressor and repair it.

AMUSING SITUATIONS:

1. **Operator's ignorance and over confidence.**

In one of the plants in Mumbai, when I visited site, I observed that the liquid is coming to compressor and I asked operator whether he has taken any action to find the cause and eliminate problem. I called the owner and owner also mentioned that the cost of compressor part replacement is high. Obviously, the liquid coming to compressor was causing early failure of compressor components. The operator tried to convince the owner in front of me that it it normal for the liquid to come to compressor. I was surprised and asked him how he is making such statement. He confidently replied that while charging the refrigerant in the plant since we charge the refrigerant liquid in the system, hence it is obvious that the liquid would come to compressor. This showed his total lack of refrigeration knowledge and I had to teach him and owner the basics of refrigeration cycle, and how to avoid liquid coming to compressor by proper designing of system components and installation of piping and its arrangement.

2. **Not having proper facilities:**

In one of the government contact at rocket launching station, we were supposed to install centrifugal machines. The machines were duly manufactured and inspected by client at the factory and he gave dispatch clearance. The site was however not ready and when machine weighing hnearly 13 Tons was to be unloaded at site, client had made no arrangements. The truck driver was also in a hurry to offload the cargo and wanted to leave the site. The client's representative and truck driver decided a novel arrangement. They tied a strong rope, one end to the machine and other end to the nearby tree and tyres were kept on the ground to reduce the impact of machine hitting the ground. The truck driver started the truck and moved slowly forward and the machine came down, however the tyres were not enough to take the load of machine and the machine tilted and fell on the ground, hitting it and damaging the shell. There was no way to repair it at site and the machine had to be brought back. It is therefore essential that proper planning is required for loading/unloading the equipment at site.

3. **Free water supply During commissioning**

In one of the govt. contracts, the condition was we should conduct 3 tests, summer winter and monsoon. When the plant was ready and customer gave us electrical connections, we needed cooling tower water for conducting the trials, the customer refused and indicated that our contract does not specify that during trials customer should give free water supply. After lot of correspondence and convincing the client and his superiors, after a delay of 4 months they amended the contract including free water supply during trials and then finally we could conduct the trials, but the plant handing over was delayed by one year as we missed one season trial.

Ramesh Paranjpey 11-03-2018.