Risk Analysis of Sour Natural Gas Pipeline when Pigging

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***Abstract*—Pigging operation is a highly risk work, the pipeline pigs may be stuck, lead to leakage accident, and even lead to fire and explosive hazard. In addition to the possible risks in natural gas pipeline pigging, it may appear some other risks in sour gas pigging operation which increases the risk of pigging operation. In line with the specific implementation flow of pigging operation, risks in the process of pig launching, operating and receiving are analyzed in detail, to guarantee the workers' safe, and ensure the pigging operation be smoothly completed.**

***Index Terms*—H2S, sour gas, pipeline pigs, risk, FeS**

I. INTRODUCTION

Sour gas mainly refers to the natural gas containing hydrogen sulfide (H_2S), organic sulfur, CO_2, saturated water and other impurities. The acidic impurities contained in natural gas have a lot of negative impact on the index of gas quality, pipelines, personnel and environment. This paper analyze the effects on the index of gas quality, pipelines and other facilities, personnel operating and the environment, and focus on the pigging risk analysis of sour gas, and summarize some specific proposals and put forward some measures to control it.

II. INFLUENCE OF H_2S

A. Influence on natural gas

The phase of water in nature gas is liquid at lower temperatures, some components in water and gas will constitute hydrate under certain conditions. H2S is likely combined with water, beside this, the hydrate-forming temperature may be much higher than the freezing point of water under high pressure conditions when the concentrations of H2S are high. Such hydrates will accumulate to be large once formed, it is difficult to deal with the pipeline once clogged by hydrates [1]. Some scholars find the hydrate-forming temperature of nature gas containing hydrogen sulfide is higher when they calculate the hydrate-forming temperature with HYSYS. For the high-sulfur natural gas, the higher the content of H2S is, the greater the impact on the hydrate-forming temperature is; and as the pressure drops, the higher the content of H2S is, the greater the impact on the hydrate-forming temperature is. H_2S has little impact on the hydrate-forming temperature when the content of H2S is low [2].

In addition, the explosion limit of methane is 5%~15% H2S explosion limit is 4.3%~45.5%.H2S widens the explosion limits of nature gas and increases the risk of explosion.

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B. Influence on the pipeline and equipment

Dry sour gas in the pipeline transportation has low causticity, but it will be strong causticity when the presence of water. The H2S in nature gas will react with water and form hydrogen ions (H+), so that the sour gas changes into a kind of highly corrosive gas. The hydrogen ions forms a positive potential combined with the iron, the positive potential forms a battery with the negative potential of pipeline, which will accelerate corrosion of pipelines, damage the structure of pipelines, lead to leak of pipelines and reduce the life of pipelines [3].

It is necessary to periodically pig to guarantee the normal operation of pipelines. Depending on operation conditions of pipelines, the pig cup can use polyurethane, neoprene cuffs or other rubber cup for special transport medium. If the pig contacts with sour gas during the operation, the sour gas may be etched into the cup, the cup will lead to break up. The implication, the H2S of nature gas may shorten the life of the pig.

The maximum allowable amount of fluid piping and pressure drop are constant. The H_2S will accelerate corrosion of pipelines, increase corrosion products and the amount of fluid and hydrates, which make pigging cycle, become shorter, increasing the risk of pigging naturally.

C. Influence of H_2S on human and environment

H_2S is an acute highly toxic gas, if people inhaled high concentrations of H2S in a short period of time can be deadly, low concentrations of h2s also have effect on eyed, respiratory system and the central nervous. Notable, we can't on the strength of rotten eggs smell determine whether the h2s exist, because high levels of h2s can palsy olfactory nerve, so it is hard to sniff strength by flavor to determine the dangerous concentration. Different concentrations of H_2S have different effect on people. Please see under specific shown in table 1.

Dry FeS will be generated in sulfur natural gas. The characteristic and the risk of FeS are:

(1)FeS powder liquidity is poor, if powder run into remit tubes, seat, and elbow and so on .It is not easy to discharge. It may cause the valve can't be turn off in place, so the leakage send tubes, filter unclean row, and may cause pollution of the tube jams.

(2)The ignition point of Fes is low, in the air with oxygen contact in moral temperature will be quickly exothermic oxidation. Forming a spontaneous combustion and fired flammable other things, causing fire even explosion pullet the environment .It belongs to major safety concerns.

III. CONTAIN SULFUR NATURAL GAS RISK ANALYSIS

After sulfur, the natural gas will effect on pipe, equipment and personnel also makes clear tube risk bigger. The following sulfur gas pipeline clear tube work is divided into serve tube and clear tube and pig send, pinging , pig receive

three stage has carried on the risk analysis.

A. Analysis of risk when sending pig

After some serving ball risk analysis, arguing that serve ball in the main risk factors for blocking card clear tube device(in the cylinder won't be able to serve in issued),serve tube in natural gas, not completely empty put serve tube valve failure poisoning, fire, and so on.

During the serving ball, the pressure and flow of tube loss from bypass. Pig with size of error, will lead to a string of gas produce phenomenon. The clearing tube pressure is not enough, clear tube device can't get enough serve tube can't get through pig sender barrel. The wrong place of pig also causes pig blocking. Before sending Pig workers will check the valve serve put empty and emissions valve is in a completely closed. Confirm the size of Pig and to be placed right. Slow increase pressure in right value, make clear tube device can get through the smooth diameter section.

If serve tube in natural gas did not put completely empty, open blind disk, not only can cause damage personnel, poisoning, but also the escape sulfur natural gas is easy to lead to fire or explosion. Staff to strictly according to operating procedures, in turn on the blind disk, make sure serve tube in pressure condition, and confirm the valve closed, use flammable gas call the police to get rid of empty instrument put gas testing to ensure that the security personnel cases to serve.

If staff didn't regular maintenance for the valves of send receive device. The quality of valves is poor and improper operators such as improper operation will lead to the valve failure, make valve won't be able to give full play to its normal switch function, leading to gas leak, even fire explosion, leakage of natural gas sulfur may also contain led to the personnel, poisoning deaths, make the risk of clear tube increased. Staff should be Regular maintenance for the valves of send and receive, make it can be use all the time. Choose the qualified valve. Operators in switch valve switch to correctly, avoid the valve failure cause by Non-standard operation.

Table 1: Effects of different concentrations of H_2S on human [5]

Concentration(mg/m^3)	Response time	Toxic reaction
0.035		Sense of smell
0.4		Obvious smell
4-7		Moderate intensity
30-40		Although the smell is strong, still can endure this is likely to cause local irritation and systemic symptoms of the threshold concentration.
70-150	1-2 hour	Eye and respiratory irritation symptoms. Long term exposure can cause sub-acute or chronic conjunctivitis. Inhalation of 2-15min is the occurrence of olfactory fatigue.
300	1 hour	Cause serious reaction to the eye and respiratory mucous membrane to stimulate the symptom, and cause the nervous system to inhibit, 6-8min is the appearance of acute eye irritation symptoms. Long term exposure cause pulmonary edema.
760	15-60min	May cause life-threatening risk of pulmonary edema, bronchitis and pneumonia. Contact time more elderly, causing headaches, dizziness, excitement, unsteady gait, nausea, vomiting, nose, and throat hair dry and pain, cough, difficulty in urination.
1000	Few seconds	Soon to cause acute poisoning, appear obvious symptoms of the whole body. Begin to breathe faster, and then breathe the paralysis and death.
1400	immediate	Coma and respiratory paralysis and death, unless immediately artificial respiration. The concentration of smell immediately fatigue, its toxicity and similar hydrogen cyanide.

Risk analysis while pigging

The pig is very likely to be invalid, blocked, loss information etc. during pigging.

The cups on the pig may be corroded in the acidic liquid, even be invalid. The risk will be easier to happen when there is H2S in the gas. We should use better quality, acid-resistant, corrosion-resistant cup to prevent corrosion.

Pig jam in the pipeline is most likely to occur, and it's the greatest risk when pigging. The local deformation, poor cleanliness and some special structures such as tees and elbows fallacious design of the pipe may cause the pig jam. In addition, the H2S in the pipe makes it easier to bring more dust and impurities, it increased the risk.

To avoid pigging jam occur, ensure the pig transits the special structure smoothly. The local deformation as well as all the tees and elbows along the gas pipeline should be checked in advance, and make the irrational structures are transformed or replaced.

Information when pigging includes personnel information and pigging information.

Personnel information lost means when communication device loses signal, low battery or malfunction, the field command can't get the first-hand information, and the workers can't receive the notification timely for the next move. Pigging loss of information is known as pigging equipment missing, it specifically refers to the monitor cannot get the sound when the pig through each detection point, the worker cannot properly determine the specific location of the pig, the state of the pig is without the range of monitored. The corrosion of the sour gas to the pig may cause the monitor

become invalid, it increased the risk of losing information.

A. *Analysis of collect balls job risk*

The main risk factors during catching the pig include pigging jam, the pig receiver not free vent , the valve on the pig receiver out of order, the pig burst out of the bling ram, fire and poisoning, etc. The causes and control measures of the valve on the pig receiver are similar to the case of valve malfunction on the pig launcher, so I don't repeat here.

The main reasons cause the pig jam during the operation of catching the pig are the main channel cylinder valve is not fully open , the seal between the pig and the pipe become weakened, there is altitude difference between the sending and receiving ends, the pushing pressure or displacement is not enough, and so on. The workers should check the valves in advance, make sure the valve on the receiver is fully open, increase the outflow and pressure to proper point.

If the operator opens the blank cover before the gas in the pig receiver is not free vent completely, it could cause personal injury, and the escaping gas mixed with dust can even cause fire, explosion, poisoning and other accidents. Staff should strictly follow the rules, before opening the blind, to confirm tee barrel pressure and confirm the valve closed, to ensure that natural gas is completely vented and cylinder pressure drop to zero and then turn the blind plate close and extract the ball.

Generally the quality of the pig is great, it can cause a huge impact on the blind, it is likely to cause blind damage or burst accident, and it brings threat to field staff. In addition, the vibration would impact the other equipment and instrumentation in the technology area or cause varying degrees of damage. In order to reduce the occurrence of such accidents, the staff should be serious and responsible, complete the pigging job quickly as possible.

The fire risk mainly happened when receiving the pig. When the blind is open, a small amount of the remaining gas which is not completely replaced, and a certain amount of dust get contact with the air, if there is fire it could cause fire disaster. During the discharge process, a lot of dust impurities along with venting gas is discharged into the slop tank, since natural gas is water-insoluble, a lot of natural gas would escape from the water and spread, if it could not be controlled may cause large-scale fire or explosion. Sour gas is likely to produce FeS in transport, as described in 1.3, FeS can easy auto ignite, even lead to serious fires.

During receiving the pig poisoning, the workers may be poisoned at the process of attaching to dust or cleaning the receiving barrel. Such the operating personnel should wear the gas masks when receiving the pig.

IV. Conclusion

Condensate and hydrate are more likely to appear if there is H2S in the natural gas, the acid gas could accelerate pipeline corrosion and make the pigging cycle shorter, the escaping sour gas or venting gas could result in staff poisoning, fire, or explosion. The failure possibility of the cup of pig in the process of pigging is large. All of the above show that the risk becomes more when transporting the sour gas.

Combined with the above risks, t the following measures are suggested: select some anti-H2S material to make the cup; add gas corrosion to the gas; Apply a protective layer to the pipe; workers wear gas masks, labor supplies when receiving the ball. In short, check all safety measures before pigging to reduce the risk as possible from all aspects.

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