Purchasing Used Pumping Units -

Considerations That Should Be Made

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Abstract

In these days of budget constraints due to unstable oil and gas prices, many companies have begun purchasing more and more used production equipment, including pumping units. In some cases they have been able to reduce "up-front" capital expenditures only to later find that there can be significant costs in repairs to this same equipment. This paper will examine the precautions and considerations that should be made before the purchases are finalized. We will review what we consider the six (6) major areas of concern: 1) the age and history of the pumping unit, 2) the gear reducer, 3) the unit's structural integrity, 4) the structural bearing assemblies, 5) additional equipment included in the purchase and, 6) the reputatation of the used equipment supplier. While we recognize that there are many used equipment dealers supplying quality reconditioned equipment, the purpose of this paper is to educate the buyer about what to look for when preparing to make this capital expenditure.

Unit Age and History

Both age and history are an integral part of the buying decision, however, it is sometimes hard to accurately determine either. Many companies have set limits on how old a unit they will consider for purchase and while this is a good rule to follow, one must be able to determine the age for themselves rather than relying on the supplier to tell them the age. LUFKIN and American made age determination rather easy but other manufacturers were not so helpful. On all LUFKIN pumping units, there is a live order number stamped on both or at least one of the name plates on the unit. On the "TC" models (those manufactured before 1956), this number is only on the gear reducer tag and is either a five (5) or six (6) digit number. On the API model units, this number is always a six (6) digit number and appears on both the reducer tag and the structure tag. Also, this number is preceded by the unit serial number and will appear as L123456D-456789. Again, the last six (6) digits identify the year of manufacture. Figure 1 shows the beginning order number for each year from 1935 through 1995.

American Manufacturing started stamping the date of manufacture on the structure tag in the mid 1960's. If the gear reducer is a split type (two piece), then it was manufactured prior to 1960. Also, American units have two serial numbers, one on the reducer and one on the structure. The structure's serial number is used to look up the unit on microfisch and therefore is the most important of the two.

CMI and later Baker Torquemaster units have the year of manufacture stamped on the gear reducer tag and incorporated as part of the reducer serial number. These units were only manufactured from 1980

through 1989.

It is sometimes hard to determine the exact age of all other units. During the "boom" years of the mid 1970's to the early 1980's, there were some 200 + pumping unit manufacturers in the United States alone but by 1986, this number had dropped to less than ten (10). If a pumping unit has a less familiar name, odds are it was manufactured during this era and should be inspected thoroughly as the integrity of these units is very questionable. Also, parts availability for these "boom day" units is almost non-existant.

Of the more significant manufacturers, a good source for age determination is through the use of composite catalogs. You may have to scan a number of books to find the unit in question, but one can almost always find the approximate age and additional useful information via this source.

After the pumping unit age is determined, it is a good practice to try to uncover the history of the equipment. One way to do this is to ask the supplier who the previous owner was so that you can determine what kind of maintenance program the unit had. It is also helpful to know where the unit came from. If you know the operating depth and production rates, you can roughly estimate the load the unit was subjected to.

If this information is unavailable, you can sometimes go to the original equipment manufacturer (OEM) to find where and to whom the unit *originally* shipped. This information can sometimes help in finding someone familiar with the unit and/or its operating conditions.

Knowing the unit's work history prior to a personal inspection of a particular pumping unit is very helpful. For example, if the unit is very old, spare parts availability should be a concern. If the unit was heavily loaded at the gear reducer, particular attention should be paid to the gear wear to help in determining what life should be expected from these gears. If the structure was heavily loaded, attention should also be paid to the unit structure and structural bearing integrity. Also, knowledge that the pumping unit to be inspected has had a poor maintenance program during its life should cause one to be even more cautious during the inspection process.

If it is impossible to personally inspect the unit prior to purchase, it is advisable to seek the services of a reputable independent inspector. This should be someone who you can trust to give the unit a thorough and unbiased inspection and someone willing to be held accountable for anything not found and reported. As a last resort, should a pre-purchase inspection be impossible, an agreement should be made to allow for the return of the pumping unit after delivery if the unit quality is not what was reported and expected.

Pumping Unit Inspection

A thorough pumping unit inspection is the key to making an informed purchasing decision. As a guideline to the inspection process, the following should help the buyer determine the unit quality and identify areas of concern. Undoubtly, the most important component of the pumping unit is the gear reducer, particularly the gear train, and it is extremely important for this item to receive the most attention as gear reducer repair can be very expensive. Of course, all components should receive equal attention and these suggestions should be helpful in evaluating the mechanical condition of all of the

major pumping unit components.

Gear Reducer

While it is desirable to inspect the gears in several different positions, it is not always possible to rotate them. When you do not have the opportunity to roll the gears around to inspect them, it is important to know where the peak torques occur around the circumference of the slow speed gear. Figure 2 illustrates the approximate location of the maximum upstroke and downstroke peak torque loads for a conventional unit. If one desires to inspect a slow speed gear at these points, the reducer must be rotated until the points marked "X" are visable from the inspection opening. It should be noted that if the cranks are at the 12 o'clock or the 6 o'clock position, one of the two points marked "X" will be approxmately straight up and easily viewed from this inspection opening. If the unit being inspected is still on the well, the cranks will usually be in one of these two positions. Also note, you will probably not have a dynamometer card to precisely show the loads but they will usually be in this approximate position. Pitting caused by overload, noted at the two peak torques, are illustrated in Figure 3.

By far, the majority of gear tooth failures are due to pitting which is caused by overloading the surface of the gear tooth. The overloaded flanks of the gear teeth will develop conical shaped pits or cavities which gradually increase in number until the entire surface of the involute shape is destroyed. Eventually, because of the bending loading on the teeth, some of the pits in the distress area will initiate fatigue cracks in the root of the teeth which will eventually cause broken teeth. Figure 3 shows typical pitting and undercutting and Figure 4 shows subsequent tooth breakage from metal fatigue. The causes of the gear tooth pitting can generally be contributed to one of the following situations:

1. The unit has been operated in an out-of-balance condition and the gear teeth are simply overloaded from a torque standpoint.

2. Perhaps the unit has been asked to carry a torque load higher than the gear reducer rating which could cause the pitting phenomena.

3. Should the two gear elements become out of alignment with each other due to perhaps a worn or failed bearing, then a localized highly loaded area will experience pitting. This condition can be identified by the typical wing and apex pitting location. That is, the pitting would be heavy on the wing of one helix and the apex of the other indicating a misalignment between the two gears in question.

Some mild initial pitting is very common in gear sets and should not be confused with the more destructive heavy pitting which can cause catastrophic failure.

In some remote instances, used unit dealers have been known to weld up the area of tooth breakage and then cut "new" teeth. If this type of "patchwork" repair is suspected or detected during the inspection process, the unit should be avoided or the gear replaced to maintain gear reducer integrity.

Another questionable gear salvage technique is somtimes used to save a worn or pitted low speed gear. This is to recut the gear and manufacture a new low speed pinion to operate with the recut gear. Basically, this entails pressing the slow speed shaft out of the gear so that it can be mounted in a gear cutter, turning down the gear outside diameter slightly, and carefully recutting the gear. Obviously, the gear tooth is made thinner and it is necessary to increase the thickness of the slow speed pinion so that the resulting backlash between the two gears is acceptable. If only small amounts of metal must be removed from the damaged gear, the torque rating of the gear set would be reduced only nominally. However, one should realize that the thickness of the gear teeth will be reduced and thus the strength of the gear is less than what it was when it was new. Another disadvantage of this procedure is that the sets become non-standard and it will be up to the operator or user of the equipment to document the change so that should further repairs be necessary, the correct parts are supplied.

Scoring, or vertical pull marks, caused by marginal lubrication or lubrication breakdown, can also cause destruction of the gear tooth's involute shape. In a pumping unit reducer, one of the functions of the lubrication oil is to reduce the friction between the mating gear teeth by providing a very thin cushion of lubricant between the active teeth. When this lubricant cushion breaks down, then scoring can take place. Figure 5 shows the pinion of a reducer which is over ten (10) years old. In this instance, the lubrication lost effectiveness and scoring has resulted. The age of the lubricant is unknown, however, it probably went far past what is recommended by the manufacturer. With this in mind, it is always recommended that the gear oil be changed prior to purchasing a used pumping unit. Depending on the severity of the scoring, new gear oil can help smooth out the vertical pull marks and reduce additional damage.

Being able to identify bad or marginal gear oil will help determine if the oil has been changed or if the oil needs to be changed. After collecting a typical sample (about a pint) in a transparent container, a visual inspection will expose possible dirt, sludge, water emulsion, or other forms of contamination. Also, keep a sample of new oil for comparison. If the lubricant has any of the following conditions, check with your supplier about replacement:

1. An acid or burnt odor would indicate oxidation of the oil to the point that it should be replaced.

2. If sludge is observed in the used sample or in the gear reducer housing, the oil should either be replaced or filtered to remove the sludge. Since sludge is usually found in reducers that have not had their lubricants changed in a long time, filtering may only remove the sludge in oil whose additives have already broken down to the point of ineffectiveness and replacement may be necessary.

3. If water is found in the sample, the water should be completely drained from the sump. The presence of water in used oil can be detected by placing a drop or two on a heated metal surface. Bubbling and spattering will occur with as little as 0.1% of water present in the oil. More than about 0.2% water by volume suggests an oil change.

4. If metal is detected in the oil or in the oil troughs, filtering is again recommended to remove the metal particals. It should then be determined whether the metal came from pitting in the gear teeth or from pitting or wear in the reducer bearings. Appropriate action or further inspection should then take place.

LUFKIN recommends that if rigorous laboratory testing of the oil is not practical, then replace the oil every 18 months as a precaution against a change in viscosity, a loss of the additive package, or an increase in the acidic condition of the oil. Since this recommendation is rarely followed in the field, it is important that the oil quality be tested and the oil changed, if necessary, while the reducer is in the shop for repairs or while the complete unit is being readied for resale. Figure 6 shows the recommended oils for enclosed gear reducers as selected by oil company lubricant engineers.

When inspecting the gear reducer housing, pay close attention to indications of leaking or leakage at the bearing carriers, parting line, and any other area that might indicate a crack in the housing. Small cracks in the reducer housing can usually be repaired by a good cast iron welder except in those cases where the crack extends across the parting line or through one of the housing bores. These two areas are precision machined and welding repairs to these areas are difficult to finish back to its original surface and will continue to leak or will potentially re-crack and possibly cause extensive damage to the housing and gear train.

Inspect the cranks to see that they are still aligned with each other properly. Both LUFKIN and American put a "crank phase mark" on the crank and the crank shaft. This is done at the factory when the unit is built and consists of a chisel mark which contacts both components. If the cranks are out of phase, these marks will be visibly out of line with each other. Should this be the case, and the unit is allowed to run in this condition, the wireline will move in a "figure eight" type motion and the misalignment may cause premature failure of the structural bearings and the wireline.

Also inspect the crank pin holes for wear. If there is noticeable wear or fretting in the crank pin hole, crank pin movement in the hole has occured. Should this fretting cover more than 15% to 20% of the crank pin hole, the hole should be bored and a sleeve installed.

Unit Structure

The unit structure should be inspected for bent or cracked components, or questionable repairs to previously damaged components. The structure consists of the following members:

1. Walking Beam
2. Horsehead
3. Samson Post
4. Pitman Arms
5. Equalizer
6. Unit Base and Gear Reducer Sub-Base

It is most important to closely inspect each of these members as they can indicate the history of the unit. If there has been a catastrophic failure to the unit, and the damaged components of the structure were repaired and not replaced, you should see some indications of this in your inspection. One should be extremely cautious of these units as we have seen continuing problems that were ultimately corrected by finally replacing the damaged components. This was not only bothersome to the producer but costly as well.

You should also inspect for cracks that should be repaired before the unit goes back into operation. These cracks will usually be found by looking for rust stains indicating a metal to metal movement. On the walking beam, pay particular attention to the areas around the equalizer bearing, center bearing and any areas where factory gussets are located. If non-factory gussets have been installed, inspect them closely and try to determine the reason for their installation. On the equalizer, check the areas around the equalizer lugs and the gussets. On the unit base, check the "runners" in front of the gear reducer sub-base and where the sub-base is welded to the base or "runners." This is especially true if the samson post third leg is bolted to the unit base, not the unit sub-base as in newer model units.

If the "runners" have been repaired previously, be aware that problems may still exist. If the repair was not done properly and the "runners" not precisely aligned, further cracking will result. Any time repairs to the "runners" have been made, it is advisable to install expansion material between the unit base and the concrete foundation to help cushion any movement that could result in further cracking.

On the horsehead, look at the way the wireline has been tracking. This could indicate how the unit was installed (unlevel from side to side) or could indicate an equalizer bearing or center bearing that has failed and dropped into a misaligned condition. Closer inspection of these bearing components should then be made.

To check the straightness of all of these members, visual sighting should first be made. If there is any indication that something may have a twist or bend to it, a level and stringline should be used to verify. Most of these members can be straightened with the use of a press operated by an experienced pressman. In cases of severe bending or twisting or where creases to the metal are involved, component replacement is recommended.

It is also recommended that the critical bolts, nuts, and washers be inspected and replaced if they appear to be of questionable quality. Age of the bolts is a good reason to replace them as is heavy rust or damaged threads. Bolts are relatively inexpensive, but when they fail, they can cause thousands of dollars of damage to the pumping unit.

Finally, the wireline should be closely inspected for frays, broken strands, flattened rope or severe rust and/or oxidation. Any of these situations indicate the need to replace the rope. The wireline is also a fairly inexpensive item, especially when replaced while the unit is in the shop for repairs. Just as with broken bolts, a broken wireline, while the unit is in operation, can run repair costs much higher than the rope itself and, in some cases, cause many days of downtime while repairs to the unit, wellhead, and/or rod string are being made.

Structural Bearing Assemblies

The structural bearing assemblies consist of the following:

1. Center bearing assembly (Saddle bearing)
2. Equalizer bearing assembly (Tail bearing)
3. Crank Pin bearing assemblies (Wrist pins)

If possible, it is always best to inspect structural bearing assemblies after they have been disassembled. The inspection of an anti-friction bearing involves visually inspecting the surfaces of the rollers and all visible raceways. Any evidence of pitting, etching, or spalling are reasons for replacing the damaged bearing. Figure 7 illustrates both spalling and pitting due to marginal lubrication, misalignment, and/or overload. Figure 8 illustrates a bearing failure caused by corrosion from moisture on the bearing raceways.

Inspection of the shafts for the structural bearing assemblies should include looking for any damage to the shafts caused by either a failed bearing allowing the shaft to move into contact with a bearing retainer or any grooves cut into the shaft by seals. Any grooves under the seal area will allow the seal to leak when a new seal is installed. If the seal area is grooved just slightly, then a very thin, hard sleeve can be installed over the grooved area to provide a hard smooth surface for the seal to work against. If the grooving is excessive, then the replacement of the shaft may be necessary. The extent of the grooving is a judgment call and is better left to experienced pumping unit repair technicians. The important thing to remember is that just replacing the seal of a grooved shaft will only work for a short time before the seal is leaking again.

If bearings must be inspected while they are still assembled, the following steps should be taken. Check for shaft wear into the retainers which would indicate a failed bearing. If the bearing retainers can be removed, then the condition of the races of the bearings can be determined by using a short piece of wire, like a paper clip that has been straightened, to "feel" the raceways between the bearing rollers to determine if there are any pits or spalling present. Even the slightest pitting should be detected and would necessitate further, more indepth, inspection. Inspection of the grease may show metal flakes that would also necessitate a closer inspection. Crank pin bearing assemblies will always fall into this catagory as all manufacturers' retainers can be removed and inspection made in this manner. If the crank pins are not installed in the crank, then the inspection of this assembly should include looking for any type of fretting corrosion that has taken place between the crank pin hole and the pin that would have been caused by slight movement between the two parts. This fretting corrosion actually removes metal between the two parts and can result in a loss of contact between the two surfaces. If this loss of contact is more than 15% to 20%, then the crank pin itself should be replaced.

If the bearing retainers cannot be removed, the bearing should be rolled slowly to feel for any rough areas indicating a closer inspection is required. One should also pump grease into the housing to check the integrity of the seal and to inspect the grease that comes out of the relief for metal flakes. Figure 9 shows the recommended grease for pumping unit structural bearing assemblies.

In all instances, we feel the oil seals should be replaced and the grease in the housing purged to alleviate problems down the road. It is always better to replace the seals and grease when the unit is being reconditioned rather than encountering further expenses at a later date.

Additional Equipment

Additional equipment, for the purpose of this paper, includes the following:

1. Counterweights
2. Crank Guards/Belt Cover/Safety Ladder
3. Safety Signs/Warning Signs
4. Concrete Foundation (Block)

While some or all of the above additional equipment may or may not be included with the used pumping unit you are purchasing, there is some knowledge of these items you, as the buyer, should have.

Counterweights

It is very important to know, before the unit is purchased, how much effective counterbalance is required for your application. In some cases, the required counterbalance is not included with the unit and therefor not included in the price of the unit. In this situation, you would need to determine the required amount of counterbalance and then pay additional money to acquire these counterweights. In other cases, depending on the brand pumping unit you are purchasing, these weights may be very difficult to locate and you are left with an underbalance (overload) situation.

It is also important to insure the proper size and number of counterweight bolts are included to attach the weights to the cranks. It should always be clear, in the pricing agreement, that if these items are not on the unit or are not of the proper size, there is some way to correct the problem.

Crank Guards/Belt Guard/Safety Ladder

While not important to the operation of the equipment, the crank guard, belt cover, and safety ladders are very important in relation to the safety of those working around the pumping unit. It is therefore crucial that, if these items are supplied, they be in conformance with the current edition of the API RP 11ER entitled "Recommended Practice for Guarding of Pumping Units".

All guards and safety features, whether supplied with the unit or not, should be installed and operable before the unit is placed into operation.

Safety Signs/Warnings Signs

In an effort to increase the safe operation of pumping units, LUFKIN developed safety/warnings signs to be placed in conspicuous locations on and around the pumping unit. These signs are placed on both new and used units to make the operator, his employees, and contractors working on or near the unit, aware of potential hazards. Figure 10 shows the content of and location for the placement of these signs.

Since safety is so important, it is necessary that the supplier of oilfield equipment posing potential hazards

go to great lengths in identifying these potential hazards and warning all who may possibly be working in these danger areas. If these warnings are not in place and no indication of an effort to inform those at risk has been made, liability for an accident could be very costly.

Also, each unit should be delivered with an Installation Manual. Like all machines with heavy moving parts, there are potential hazards in the installation and operation of the equipment. These hazards can be reduced if the unit is properly installed, operated, and maintained. All personnel who install, operate, and maintain the unit should read and understand this manual and be trained to use the machine in an appropriate and safe manner. It is your responsibility to request this manual if it is not with the unit when the unit is delivered.

Concrete Foundation

An adequate foundation is essential to the satisfactory operation of a pumping unit. Although there are circumstances under which substitutes may be acceptable (see API Recommended Practice RP-11G), a reinforced concrete block is usually the best foundation. Manufacturer's foundation prints will show the location of foundation bolts or hold-downs and suggested outlines of the foundation; however, the actual size and depth of the foundation depends on local soil condition. Since you will, in most cases, be acquiring a used concrete block, it is imperative that it be free of severe cracking that penetrates the concrete top and side surfaces. A poor foundation can lead to serious failures to the pumping unit structure. It is also very important that the tie-down bolt anchoring material not be deteriorated due to rust or oxidation in such a way that the bolts fail to adequately maintain the required torque to hold the unit in place.

Reputation of the Supplier

As is the case with the purchase of any used/reconditioned piece of production equipment, it is also important to become aware of the supplier's reputation. Therefore, before the transaction is completed, the buyer should ask for references, or a customer list, and then contact these customers and ask the following questions:

1. What experiences have they had with units purchased from the supplier?
2. Have they received units as they were described and in good working condition?
3. How were warranty problems, if any, handled?

By asking these questions, one should get a good idea of what to expect when or if the purchase is made. No one wants to spend a large amount of money for equipment that will continually need attention. It is also comforting to know that, if there is a problem, it will be corrected at no additional cost to the buyer.

There are also questions that should be asked of the supplier himself. If the supplier is reluctant to answer these questions, the buyer should be reluctant to make the purchase. These questions should include:

1. Are OEM replacement parts used in the repair of the used unit and if not, why not?
2. For units no longer manufactured, how are replacement parts acquired or how is the unit repaired?
3. What is the warranty period and what is covered?
4. What is the financial condition of the supplier's company and will the company still be around should a warranty claim be made?

It is important that the used unit supplier use OEM parts in the reconditioning of the used equipment to insure that the new parts meet the design requirements of the original machine. The potential for an injury due to a failed non-OEM part is real and should be a concern to the used pumping unit user. It should also be important to the user that the supplier of the used pumping unit be in good financial condition and have the necessary insurance should a personal injury associated with the used unit occur.

Of course, not all brands on the used unit market are still manufactured, so it is necessary to build these parts either at the supplier's shop or in a local machine shop. In these cases, the buyer should visit the shop and see how the parts are manufactured. If the shop is disorganized, messy, and with little or no quality control, you can assume that the parts coming from the shop are comparable. The visit to the reconditioning shop or machine shop will go a long way toward telling the buyer the kind of equipment he will be receiving.

Conclusion

The above guidelines are intended to help the buyer become familiar with the equipment being purchased. There may be other items included in the package such as motors, controls, belts, etc., but this paper was intended to consider the pumping unit and its components only. Any additional equipment should be just as closely scrutinized. Since today's prices of used reconditioned pumping units are from 50% to 85% of new unit prices, it is important that the buyer be aware of any hidden cost associated with the potential purchase; that what the buyer pays is in line with what the equipment is actually worth. Based on a comprehensive inspection, the decision should then be made as to whether the equipment is worth the asking price or whether it would be more prudent to buy a new peice of equipment. If possible, any questions concerning the repair of the pumping unit should be directed to the original equipment manufacturer or a recognized expert in pumping unit repair.

Another part of the equation should be the potential producing life of the field the pumping unit is purchased for and whether the used unit in question will likely last as long as this estimated life of the field. Remember, these are used pumping units and all the above factors determine the quality and longevity of the piece of equipment you will be receiving.

References

1. Elliott, F. Ben, *Effect of Abuse and Misapplication on Pumping Unit Gears,* Southwestern Petroleum Short Course, Lubbock, Texas, 1962
2. Griffin, Fred D., *Maintenance of Oilfield Pumping Units*
3. *Installation Manual CU-96 Conventional and Reverse Mark Pumping Units,* Lufkin Industries, Inc., 1996
4. *AGMA Standart Nomenclature of Gear Tooth Failure Modes,* The American Gear Manufacturer's Association

Acknowledgements

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YEAR	SHOP NUMBER	YEAR	SHOP NUMBERS	
1935	23300	1965	265648	
1936	27300	1966	277217	
1937	30500	1967	287455	
1938	35309	1968	297843	
1939	39850	1969	308300	
1940	43600	1970	319152	
1941	48140	1971	329600	
1942	54000	1972	340500	
1943	56100	1973	350781	
1944	59500	1974	361975	
1945	65700	1975	371600	
1946	70760	1976	382000	
1947	77206	1977	391360	
1948	84700	1978	402900	
1949	92500	1979	415535	
1950	98460	1980	431400	
1951	108200	1981	443939	800000
1952	116170	1982	456000	802900
1953	125000	1983	464400	805760
1954	133990	1984	471200	808725
1955	144600	1985	479800	811865
1956	156000	1986	487700	814981
1957	168621	1987	491544	818209
1958	180510	1988	496254	821746
1959	193154	1989	501213	825703
1960	207534	1990	506264	830091
1961	220554	1991	511995	835183
1962	229253	1992	517708	840081
1963	242185	1993	520060	844811
1964	253703	1994	525763	849631
		1995	529935	855209

Figure 1 - LUFKIN Order Numbers Showing Date of Manufacture of Pumping Units

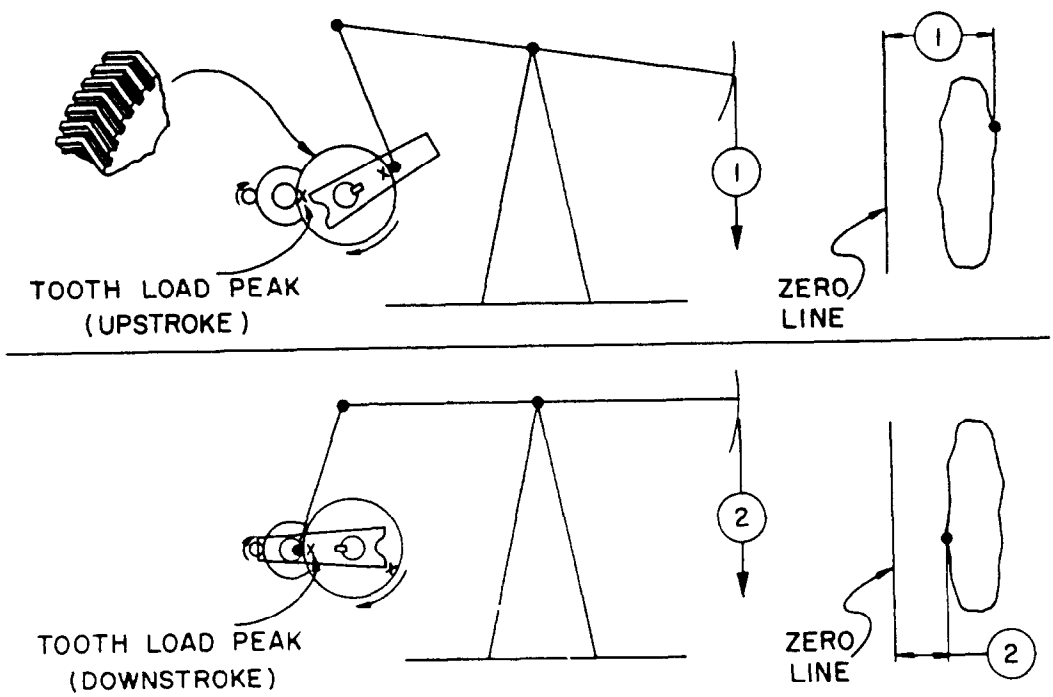

Figure 2 - Slow Speed Gear Torque Peak Locations

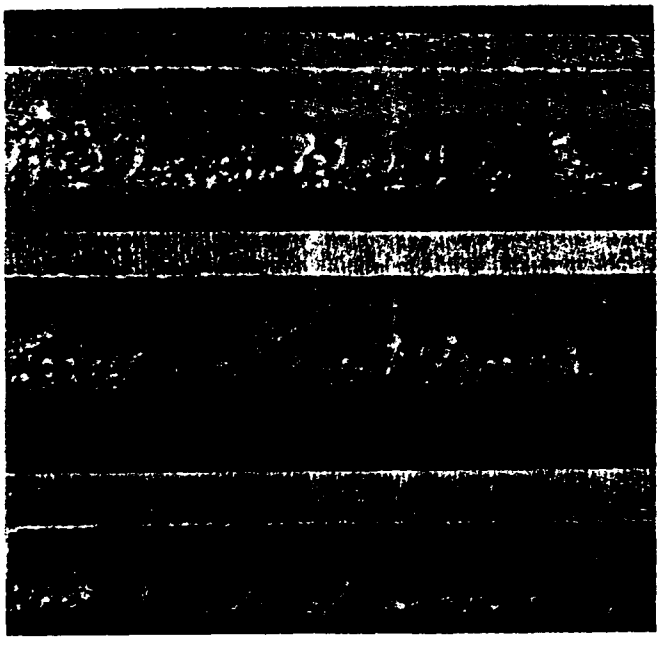

Figure 3 - Gear Tooth Pitting From Torque Overload

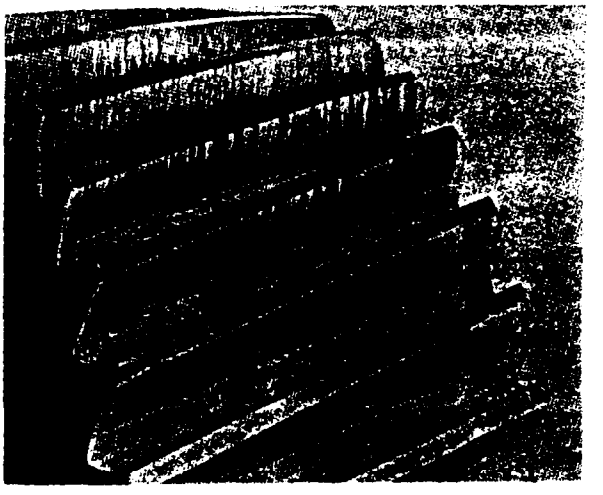

Figure 5 - Tooth Scoring From Marginal Lubrication (vertical pull marks)

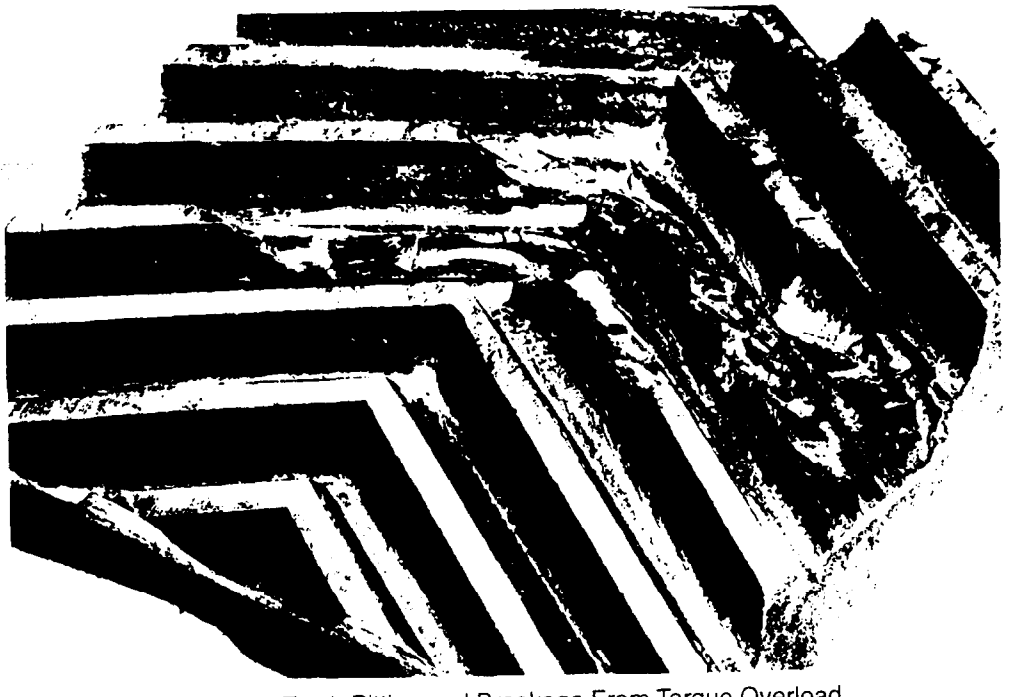

Figure 4 - Gear Tooth Pitting and Breakage From Torque Overload

EXTREME PRESSURE (MILD) GEAR OILS

AGMA NO. 2EP ISO VG 68	AGMA NO. 3EP ISO VG 100	AGMA NO. 4EP ISO VG 150	AGMA NO. 5EP ISO VG 220	AGMA NO. 6EP ISO VG 320	AGMA NO. 7EP ISO VG 460	AGMA NO. 8EP ISO VG 680	MAXIMUM OPER. TEMP.
AMOGEAR EP 68	PERMAGEAR EP 100	AMOGEAR EP 150	AMOGEAR EP 220	AMOGEAR EP 320	AMOGEAR EP 460	AMOGEAR EP 680	200° F.
PENNANT NL 68	---	PENNANT NL 150	PENNANT NL 220	PENNANT NL 320	PENNANT NL 460	PENNANT NL 680	250° F.
NL GEAR COMP. 68	NL GEAR COMP. 100	NL GEAR COMP. 150	NL GEAR COMP. 220	NL GEAR COMP. 320	NL GEAR COMP. 460	NL GEAR COMP. 680	200° F.
EP COMP. 68	EP COMP. 100	EP COMP. 150	EP COMP. 220	EP COMP. 320	EP COMP. 460	EP COMP. 680	225° F.
GEAR OIL 68	GEAR OIL 100	GEAR OIL 150	GEAR OIL 220	GEAR OIL 320	GEAR OIL 460	GEAR OIL 680	225° F.
SPARTAN EP 68	SPARTAN EP 100	SPARTAN EP 150	SPARTAN EP 220	SPARTAN EP 320	SPARTAN EP 460	SPARTAN EP 680	180° F.
EP LUBRICANT HD 68	EP LUBRICANT HD 100	EP LUBRICANT HD 150	EP LUBRICANT HD 220	EP LUBRICANT HD 320	EP LUBRICANT HD 460	EP LUBRICANT HD 680	200° F.
EP GEAR COMP. 68	ROCK DRILL OIL 100	EP GEAR COMP. 150	EP GEAR COMP. 220	EP GEAR COMP. 320	EP GEAR COMP. 460	---	350° F.
MOBILGEAR 626	MOBILGEAR 627	MOBILGEAR 629	MOBILGEAR 630	MOBILGEAR 632	MOBILGEAR 634	MOBILGEAR 636	230° F.
GOLTEX GEAR 2EP	GOLTEX GEAR 3EP	GOLTEX GEAR 4EP	GOLTEX GEAR 5EP	GOLTEX GEAR 6EP	GOLTEX GEAR 7EP	GOLTEX GEAR 8EP	190° F.
ALL PURPOSE GEAR OIL 80W	---	---	---	---	ALL PURPOSE GEAR OIL 140	---	215° F.
FLEX-O-LUBE 514 2EP	FLEX-O-LUBE 514 3EP	FLEX-O-LUBE 514 4EP	FLEX-O-LUBE 514 5EP	FLEX-O-LUBE 514 6EP	FLEX-O-LUBE 514 7EP	FLEX-O-LUBE 514 8EP	250° F.
INDIGO 50	ROCK DRILL OIL 49	ROCK DRILL OIL 78	INDIGO 84	---	INDIGO 136	---	350° F.
OMALA 68	---	OMALA 150	OMALA 220	OMALA 320	OMALA 460	OMALA 680	230° F.
GP GEAR 80	---	---	GP GEAR 90	---	GP GEAR 140	---	200° F.
GEAR EP 80	---	GEAR EP 85	GEAR EP 90	GEAR EP 125	GEAR EP 140	GEAR EP 170	200° F.
SUNEP 1050	---	SUNEP 1060	SUNEP 1070	SUNEP 1090	SUNEP 1150	---	250° F.
MEROPA 68	MEROPA 68/150	MEROPA 150	MEROPA 220	MEROPA 320	MEROPA 460	MEROPA 680	200° F.
EXTRA DUTY NL GEAR LUBE 2EP	EXTRA DUTY NL GEAR LUBE 3EP	EXTRA DUTY NL GEAR LUBE 4EP	EXTRA DUTY NL GEAR LUBE 5EP	EXTRA DUTY NL GEAR LUBE 6EP	EXTRA DUTY NL GEAR LUBE 7EP	EXTRA DUTY NL GEAR LUBE 8EP	250° F.

SPECIFICATIONS:
(1) USE HIGH QUALITY WELL-REFINED PETROLEUM OIL. Pumping Unit - AGMA #4EP (Ambient temperature down to -30°F.)
(2) RUST AND OXIDATION INHIBITORS ARE REQUIRED. AGMA #5EP (Ambient temperature down to 0°F.)
(3) AN ANTI-FOAM ADDITIVE IS REQUIRED.
(4) MINIMUM VISCOSITY INDEX OF 90 PREFERRED.
(5) OIL MUST HAVE NON-CORROSIVE CHARACTERISTICS TO ALL METALS ENCOUNTERED EVEN IN THE PRESENCE OF MOISTURE.
(6) ADDITIVES IN OIL MUST NOT ACT AS ABRASIVES.

Figure 6 - Recommended Oil for Enclosed Gear Reducers Selected by Oil Company Lubricant Engineers

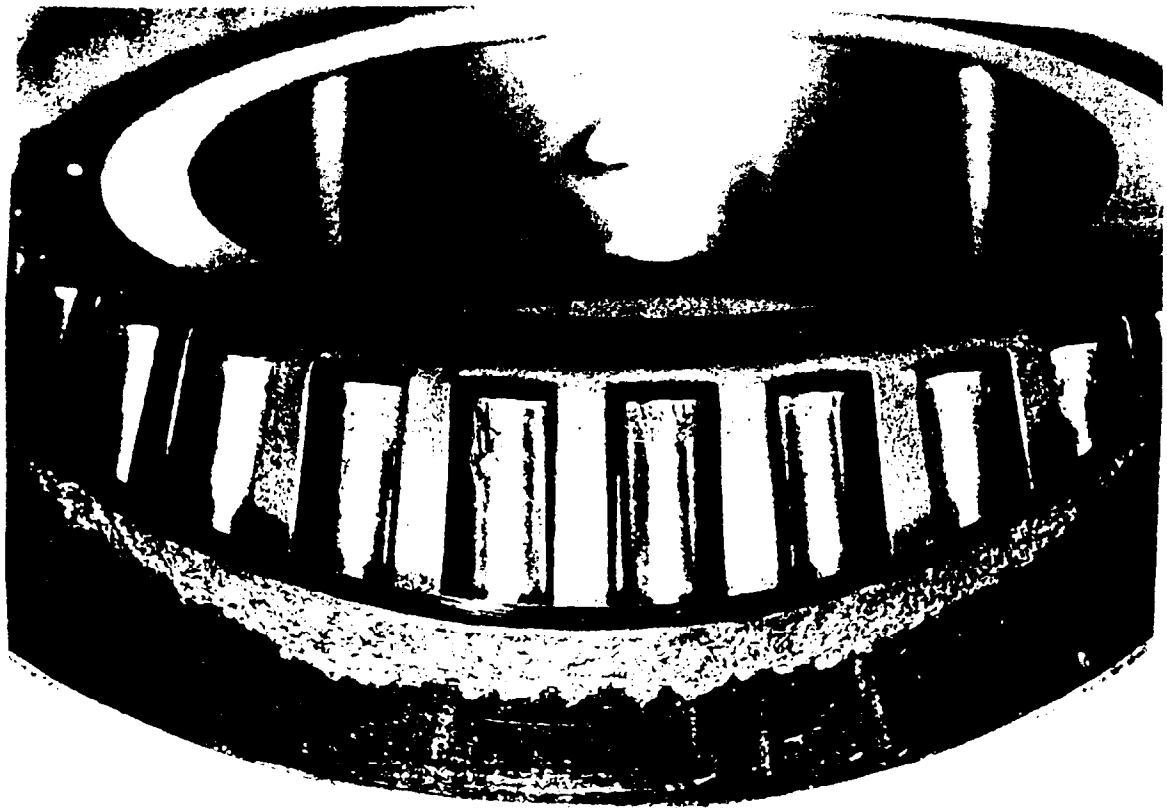

Figure 7 - Bearing Failure, Spalling, and Pitting, Due to Overload

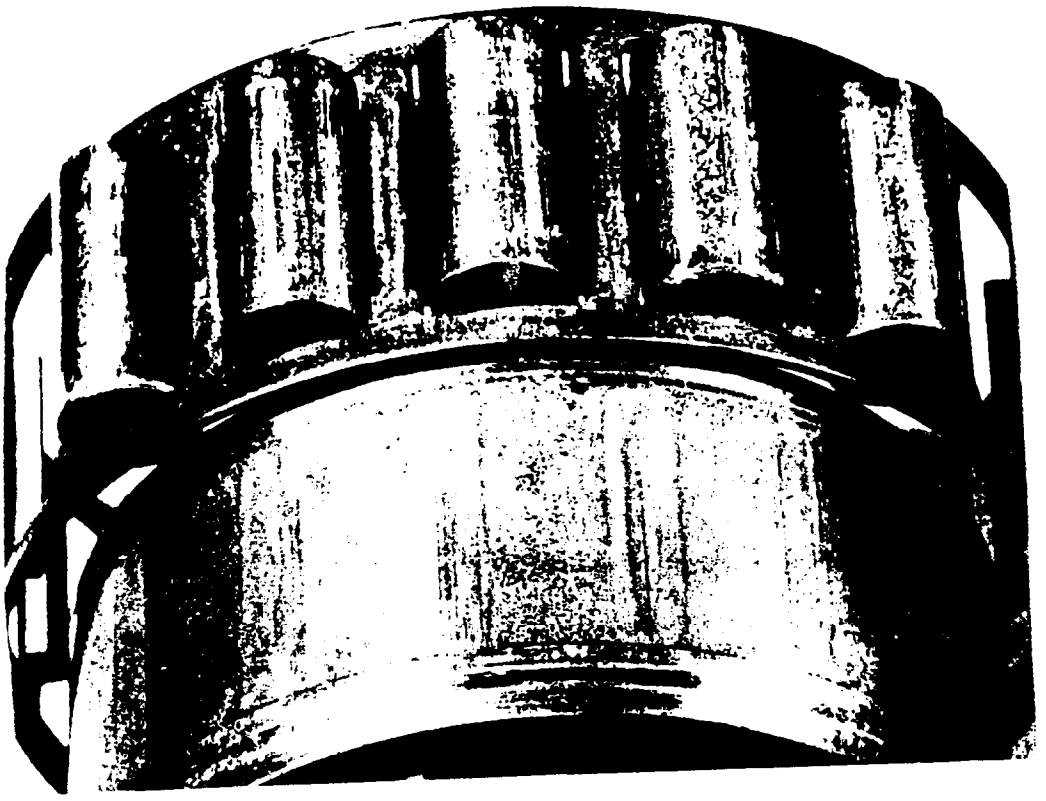

Figure 8 - Bearing Failure, Corrosion,and Wear, Due to Moisture in the Bearing Housing

GREASES FOR PUMPING UNIT STRUCTURAL BEARINGS

(SELECTED BY OIL COMPANY LUBRICANT ENGINEERS)

SUPPLIER	SOUTHERN CLIMATE (DOWN TO 0° F.)	NORTHERN CLIMATE (DOWN TO -30° F.
AMOCO	RYKON PREMIUM GREASE NO. 2 EP	RYKON PREMIUM GREASE NO. 2 EP
ARCO	LITHOLINE H EP-1	LITHOLINE H EP-1
CHEVRON	BLACK PEARL GREASE EP NO. 1	BLACK PEARL GREASE EP NO. 1
CITGO	LITHIUM EP GREASE NO. 1	LITHIUM EP GREASE NO. 1
CONOCO	EP CONOLITH GREASE NO. 1	HIGH PERFORMANCE SYNTHETIC GREASE
EXXON	RONEX MP	RONEX MP
MOBIL	MOBILITH AW 1	MOBILITH AW 1
PACER	SYNFILM SUPER MOLY	SYNFILM SUPER MOLY
PHILLIPS	PHILUBE L PLUS EP GREASE 0	PHILUBE L PLUS EP GREASE1
PRIMROSE	327 ARMOR PLATE WITH MOLY-D	327 ARMOR PLATE WITH MOLY-D
SHELL	ALVANIA EP LF NO. 2	ALVANIA EP LF NO. 2
SUN	SUNOCO ULTRA PRESTIGE #2	SUNOCO PRESTIGE #2
TEXACO	MULTIFAK EP 2	MULTIFAK EP 1
UNOCAL	MULTIPLEX EP GREASE	MULTIPLEX EP GREASE

Figure 9 - Greases for Pumping Unit Structural Bearing

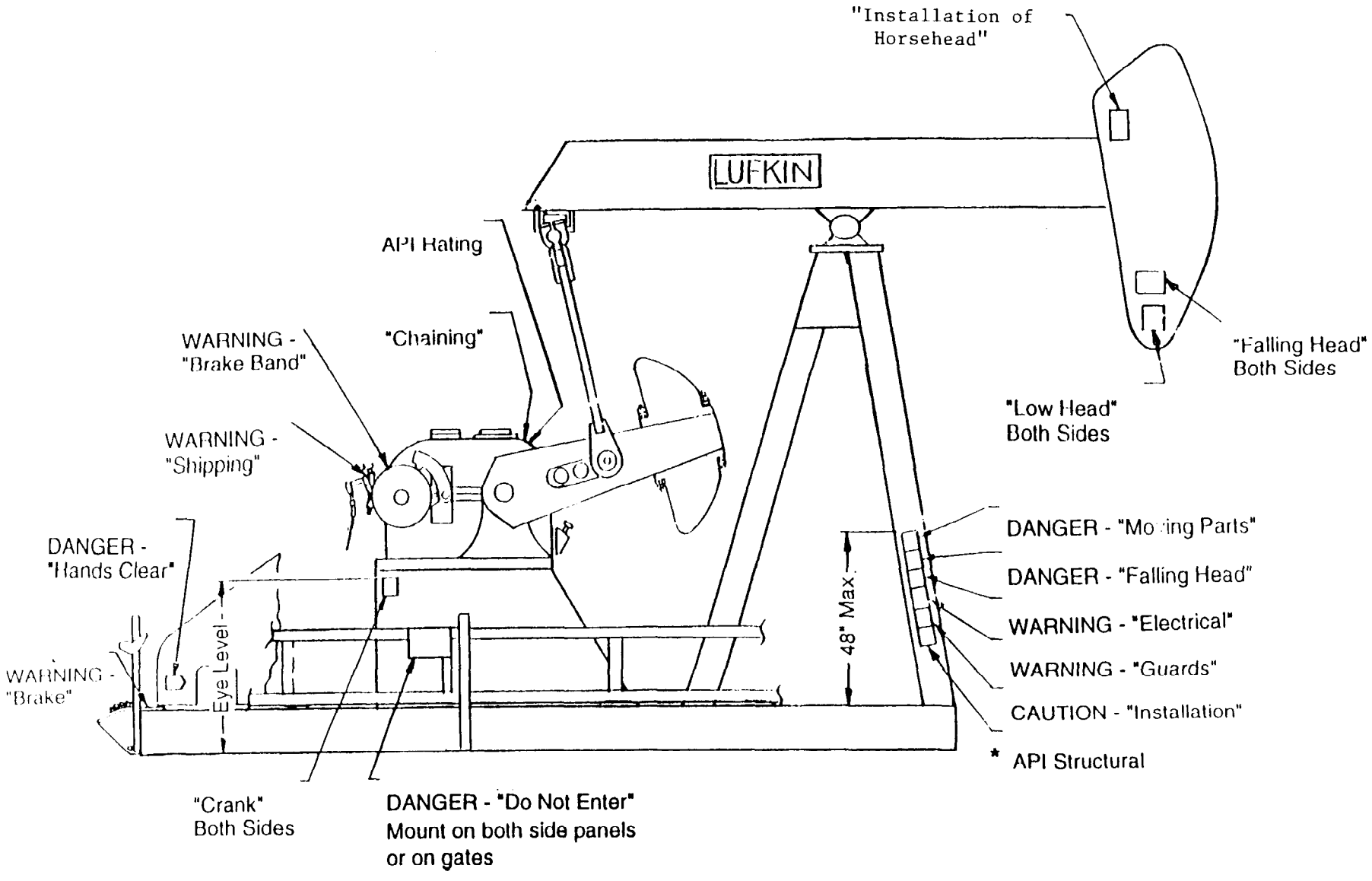

Figure 10 - LUFKIN's Safety/Warning Signs -- Content and Placement Diagram