AN OVERVIEW ON ENERGY EFFICIENT INCREASED SAFETY Ex ‘e’, PRESSURISED Ex ‘p’ AND FLAMEPROOF Ex ‘d’ MOTOR WITH VARIABLE SPEED DRIVE (VSD) FOR HAZARDOUS AREAS AND IMPACT OF SELECTION, INSTALLATION AND MAINTENANCE ON IT

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ABSTRACT

Energy Efficient Ex ‘e’, Ex ‘p’ and Ex ‘d’ Motors with VSD differ from the other standard concepts in a number of important ways. It is a concept where these motors with particular drive can save the energy and give the better performance with safety of margin which is very important for drives in the hazardous area. There are different safety aspects relating to electrical in hazardous areas like operational safety, personnel safety, Protection like Increased Safety, Pressurized, flameproof etc. All these factors interact and in circumstance where the available power level is adequate, the only acceptable form of energy efficient electrical Ex ‘e’, Ex ‘p’ and Ex ‘d’ motors with

KEY WORDS: Increased safety, Flameproof, Pressurized, Selection, Installation, Maintenance, Variable Speed Drive.

INTRODUCTION

The criteria that should be taken into consideration when making a decision on the selection and application of Increased safety motors Ex ‘e’, Flameproof motor Ex ‘d’ and Pressurized motor Ex ‘p’ in hazardous areas are temperature limit, surface temperature, arc, spark, design parameters, gas groups, zones etc. Generally these are type of protections which can be used in the hazardous areas namely Ex ‘d’ (Flameproof), Ex ‘e’ (Increased safety), Ex ‘n’ (Non-sparking) and Ex ‘p’ (Pressurized) Motors. Generally Increased safety motor has Ex ‘e’ cum Ex ‘n’ protection. These all type of motors are being used in the Oil mines, Petrochemical, Refineries, Pharmaceutical which are come under hazardous areas in the India. But in the coal mines of India only Flameproof motors are permitted. In many cases motor never runs at the rated load. Often the motors are so much over rated that with respect to the actual load that they never utilize the full power capabilities, so the operating efficiencies of such motors is generally inferior and more consumed energy.

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The most energy savings may be saved with improving drive systems by investing in the variable speed systems and the changes in the capacity of pumps. Also some energy savings were achieved with the changing the over sized motors when also improved control of reactive power could
be achieved, it would be possible during correct selection. Variable speed drives (VSDs) are potential
power savers but mostly for cases where there is sustainable variation of flow. VSDs allow loads driven
by these AC motors (such as fans compressor, pumps, conveyor belt etc.) to operate in a wide range of
speeds compared to the motors of fixed speed. Since the electrical wave generated by a variable speed
drive is with harmonics, the motor will heat up more when used with a variable speed drive than when
run off the standard power line. As a result it is necessary to install a improved or specifically designed
more efficient motor with the drive if the present motor without a variable frequency drive is operating at
or above its rated power.

If proper selection, installation and maintenance is not done timely then there are lots of
chances of flash, spark or burnt the equipment so never deviate from precautions and safety guidelines
during selection, installation and maintenance even for a minute.

CONSTRUCTIONAL REQUIREMENTS OF MOTORS

Ex ‘d’ MOTOR

The Flameproof motor must have the flameproof feature (like flamepath, gap etc.) as per the
requirement of gas group and gross volume of enclosure for motor. The flameproof joint for shaft of
rotating machine is very important and it may be arranged with motor driving end (DE) and non driving
end (NDE) in different way. There are three types of joint which are permissible as per the requirement
of flameproof namely cylindrical joint, labyrinth joint and joint with floating gland.

The cylindrical joint generally forms between shaft of the motor and both end covers of the
motor. In this joint the grooves for retention of grease is always outside the flamepath. Labyrinth joint
does not require any flame path and gap but the motor should pass in all the necessary Flameproof
test. Floating glands are permitted for electrical apparatus except Group IIC. Sleeve bearings are not
permitted for rotating electrical machines of Group IIC. A flameproof joint of a shaft gland associated
with a sleeve bearing should be provided in addition to the sleeve bearing itself and should have a
width of joint at least equal to the diameter of the shaft but not exceeding 25 mm. Shaft glands may also
be equipped with rolling element bearings with acceptable maximum radial clearance. The clearance
should be maintained between the internal fan and its hood, ventilation screws and their fasteners at
least 1/100 of the maximum diameter of the fan. In no cases the clearance should be less than 1 mm.
The degree of protection IP of ventilation opening (fan guard) for external fans of rotating electrical
machine should be at least IP 20 on the air inlet side and IP 10 on the air outlet side. But ingress
protection IP55 always is preferred. The fan, fanhoods and ventilation screws should be constructed in
such way that they can withstand high risk of mechanical danger. Motor Characteristic should be
matched with VSD, if it will be used with VSD.

Ex ‘e’ MOTOR
The terminals must be generously sized and of sufficient cross-section for required current carrying capacity. They should also be positively located, and constructed in such a way that the conductors cannot come loose or be damaged by the clamping action. Minimum clearance and creepage distances are specified between conducting parts at different potentials which are vary depending on the working voltage. Insulating material should withstand the temporary excess temperature for time $t_E$ without movement of conductors. The grading of different insulating materials is covered and also minimum creepage distances for different working voltages. Insulating Materials including thermal stability, temperature rating and strength should be of high grade. In general the ‘T’ rating must not be exceeded by any part of the motor within the $t_E$ time during normal operation, or starting or stalled in order to prevent ignition of an explosive atmosphere. The windings have to be protected to ensure the Limiting Temperature can not be exceeded in the normal service. i.e. it must disconnect the motor from the supply within the $t_E$ time if the motor is subjected to a locked rotor situation. Maximum Values for $t_E$ time for different Starting Current to Rated Current Ratios. The $t_E$ time can not be less than 5 seconds and the Starting Current to Rated Current $I_s/I_n$ ratio can not exceed 10. The Limiting Temperatures for Insulated Windings for different Classes of Insulation. Motor enclosure should be capable to withstand for impact tests. Ingress protection is required for weatherproofness of motor enclosure and it depends on the outdoor/indoor installation.

**Ex ‘p’ MOTOR**

The enclosure, ducts and coupling components should be able to withstand an overpressure of 1.5 times of the maintained max. overpressure or 2mbar, whichever is greater. The material used for the enclosure, the ducts and the coupling components shall be flame-retardant, self-extinguishing and shall not be affected by the specified protective gas or gases or by the flammable gases or vapors, in which they are intended to be used. The cover of the enclosure and the tubing should be of any non-incendive material. The cables entered inside the pressurized enclosure should be well sealed with the sealing compound. The inlet tubes for purging and the exhaust tubes for protective gas should be such that an overpressure of 5mm WC remains maintained. Doors and covers of pressurized unit should be provided with special fasteners. The minimum IP protection required for the Ex ‘p’ enclosure is IP40. All cable entries and conduit connections should be sealed to maintain the IP rating as well as to minimize the leakages of the protective gas. The maximum surface temperature of the apparatus should be less than the permissible temperature range. The pressurization may be achieved by using Pressurization by continuous circulation of protective gas method or Pressurization with Leakage compensation.

**GENERAL REQUIREMENTS OF VSD**

- Variable speed drive (VSD) supplier should furnish the detail of reactors, filters, and transformers as specified.
• The VSD unit, including all specified accessories, shall have a minimum efficiency of 85 percent at any speed from 30 to 100%. The unit should have a power factor of 0.9 or higher when operating at any speed from 30 to 100%.

• Provide the necessary electronics to avoid audible noise generated from motor due to frequency change. The unit should not increase the motor audible noise.

• The unit should include self diagnostics with a digital display that identifies fault conditions and simplifies trouble shooting. Fault indications should be retained even after a power output or an input circuit breaker trip.

• Line reactor should be integral to the drive.

• The VSD unit should have a dedicated terminal block for all external inputs and outputs.

• A bypass starter should be provided. (main input disconnect switch & an inverter input disconnect switch, if bypass starter should be provided.)

• A Local-Remote speed control switch in the Remote position should be provided.

• Indicating lamp for "POWER AVAILABLE", "MOTOR ON VSD" and for "MOTOR ON BYPASS" should be provided.

• Motor RPM meter, Voltmeter, Ammeter and frequency display meter should be mounted on the face of the unit.

• The VSD shall be provided with different protection like Over voltage and under voltage protection, Over temperature protection, Short circuit and ground fault protection, Motor overload protection, Adjustable current limiter.

IMPACT OF VSDs WITH MOTOR

• Improvement in Full Load Operation
• Low Speed Operation
• Improvement in Starting Torque
• Low Mechanical Resonance
• High Motor Compatibility

SELECTION OF MOTOR

Special features are required to these motors for hazardous area during selection and it depends on the gas groups/zones. Selection of motor, drive and its accessories are also very important factor to decrease the consumption level of power, money, time etc. some useful factors are listed below:

• Virtually every engineering discipline was used in the development of the electric motor range, which is supplied to hazardous area.

• The design of the cooling circuit should produce low noise levels for a well working environment.

• The noise levels of a motor should be low.
• The design of the fan cover of the motor should be designed in such a way that the fan blade diameter can be reduced and air can more effectively over the motor casing.
• The motor should have low starting currents while continuing to provide high starting and acceleration torques.
• The motor should have high efficiency across all loads.
• Motor should be treated with High-performance epoxy paint.
• Motor should have a stainless-steel/Brass rating plate.
• Motor should have IP 55 enclosure and a robust cast-iron and steel construction to render the motor suitable for use in hostile environments.
• There should be designed for multi mount facility for rotation of terminal box position without necessitating removal of end shields; and the fitting of pads for fan ventilation.

Selection of correct KW rating of Motor with suitable Drive

Electric motors operate at their best power factor and efficiency when fully loaded so user do not want to purchase a motor that is too big, and common sense dictates that one that is too small is even worse. During this selection process, specific gravity of the fluid is assumed one. If the fluid has a higher or lower specific gravity we must have to consider the specific gravity to get the correct kilowatts for the application. Oil refinery applications use a second factor recommended by the American Petroleum Institute (A.P.I.). This organization specifies that the factor should be used as an additional safety margin for the selection of KW of motor. These factors are:

• to 25 horsepower (18.7 KW) = 1.25
• from 30 to 70 horsepower (22.4 to 52.2 KW) = 1.15
• a 100 horse power (74.6 KW) or more = 1.10

INSTALLATION OF MOTOR

Installation of new drive alongwith motor is itself a very critical task. If installation is done properly, obviously, maintenance may be reduced. The following points should also be checked at the time of installation and at a periodic interval to be decided by the maintenance management based on operating experience. Normally, checking once in a year may be necessary.

a) Whether there is unauthorized modification to the apparatus after it passed the manufacturing stage,
b) Whether all the bolts, glands and stoppers are completely tightened and having proper size,
c) Whether the earthing is satisfactory,
d) Whether the electrical connections are tight,
e) Whether the motor fans and couplings are rubbing on any other parts like guards, cowls etc.
f) Whether the stopper box and cable boxes are correctly fitted,
g) Whether there is obvious damage to cables,
h) Whether the guards to prevent accidental contact with the apparatus are present and
correctly located,
i) Whether there is undue accumulation of dust or dirt over the motor.

MAINTENANCE OF MOTOR

Maintenance and operation of all machinery are necessary to make beneficial industry. A regular and organized scheme of maintenance may ensure continued, satisfactory and safe operation of electrical equipment. The manufacturer’s manual which gives the details regarding the maintenance of particular equipment should be followed by maintenance staff. Some time it happens when same rating of motor is not available in the inventory, the other rating of motor is being replaced by available motor and so some times it may become very dangerous. Evidence of rusting, corrosion, and deterioration of the varnish or paint should be checked and corrective action should be taken against it properly. Wherever it requires modifying the control circuit of any equipment/drive information should be given to all concerned staff. The temperature class must be confirmed with declared temperature class of motor when the damaged/burnt winding of the used motor is changed.

VERIFICATION AND TESTS ON MOTOR

Test for Flameproofness, Impact, Pressurization, Temperature class
Test for weatherproofness
Test for performance with VSD and without VSD

COMPARISION ON IMPORTANT PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Flameproof Motor</th>
<th>Increased Safety Motor</th>
<th>Pressurized Motor</th>
<th>Standard Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficient Specification</td>
<td>Must required</td>
<td>Must required</td>
<td>Must required</td>
<td>Must required</td>
</tr>
<tr>
<td>Flameproof Design</td>
<td>It is must</td>
<td>Not required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>like flamepath gap etc.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Temperature Limit</td>
<td>It depends on the application</td>
<td>Limitation upto T3 class (200°C)</td>
<td>It depends on the application</td>
<td>Not required</td>
</tr>
<tr>
<td>Terminal</td>
<td>Antiloosening type may be used</td>
<td>Antiloosening type and non-sparking type must be used</td>
<td>Antiloosening type and non-sparking type must be used</td>
<td>Not required</td>
</tr>
<tr>
<td>Internal design of motor</td>
<td>It is required</td>
<td>Most parameter like Air gap, Core length, core Diameter etc</td>
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<td>It is required</td>
</tr>
<tr>
<td>t_e</td>
<td>Not required</td>
<td>It is must</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>Cable Termination</td>
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<td>More attention is required</td>
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<td>Preferred IP</td>
<td>IP-55</td>
<td>IP-55</td>
<td>IP-55</td>
<td>As per customer requirement</td>
</tr>
</tbody>
</table>
RESPONSIBILITIES

- It is the users responsibility to ensure that the motor is protected against over-heating by the provision of an overload & temperature detector device;
- Termination for supply cables to motor terminals must confirm with the requirement of standards.
- Care should be taken with the temperature rating of the cable and the type of cable gland used.
- User must ensure that whether the concerned motor with or without VSDs have valid certificate & approval for use in the hazardous areas.

CONCLUSION

In view of the above points, the safe and satisfactory operations of the electrical motors for hazardous areas are dependent on a high standard of inspection, selection, maintenance and safety parameters. The selection, installation and maintenance is the best techniques to save the energy. If the points listed in the paper are followed meticulously a considered amount of energy, time and money can be saved and breakdowns and accident can be minimized with increasing the safety level in the hazardous area.

REFERENCES

4. IS: 6381-2004, “Construction and testing of electrical apparatus with type of protection ‘e’.”