ESP Safety Aspects

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ESP Safety - Conventional

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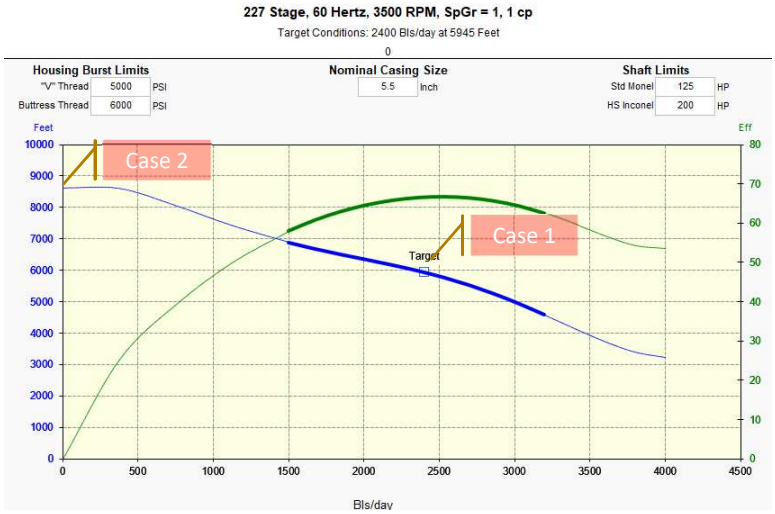
ESP Shut in Surface Pressure Awareness

- Assumptions Case 1 & 2
  - Flow line pressure 300 psi
  - Rate 2400 BPD
  - Fluid sg 1.0
  - Pump intake at 7000 feet VSD
  - 2 7/8” Tubing
  - 60 Hz operation
  - Static fluid level 1000 feet
- Variables
- Case 1 – Stable Operation
  - Producing fluid level **6000** feet
- Case 2 – Startup Conditions
  - Static fluid level **1000** feet
- **All else remains the same.**

Pump Curve for Case 1 & 2

- Case 1
  - Settled Designed for Operation
- Case 2
  - Frozen flowline
  - Closed valve
  - Closed choke
  - Check valve reversed
  - Other surface flow restrictions
  - ??
  - **Yes it does happen**



The Numbers

Case 1 - Operation @ Design Conditions

- Available surface Dead Head pressure is 1156 psi.

UOM	PSI	Feet
Net Lift		5000
Flow Line Pressure	300	693
Tubing Friction Loss		252
Required TDH		5945
Available TDH @ Operating Point		5945
Available TDH @ Dead Head Condition		8615
Delta Feet Available at Surface		2670
Delta Feet Converted to psi at Surface	1156	

Case - 2 Startup @ Deadhead Conditions

- Available surface Dead Head pressure is 3297 psi.

UOM	PSI	Feet
Net Lift		1000
Flow Line Pressure	300	~~693~~
Tubing Friction Loss		~~252~~
Required TDH		1000
Available TDH @ Dead Head Condition		8615
Delta Feet Available at Surface		7615
Delta Feet Converted to psi at Surface	3297	

Not a factor at Dead Head condition

(Conversion from Head Feet to psi is [Head Feet * 0.433 * avg sg]

Example 1 (Been There Done That)

- Bairoil WY.
- 1978
- LSU Lease (well # forgotten)
- FS Tech R Delaloye
- Startup of a high-rate ESP
  - Either a GN5600 or GN7000.
- 3” inch flow line with a Bronze (400 WOG) swing type check valve.
- Standing at the wellhead waiting for the unit to pump up.
- When the pressure gauge started it’s second revolution the race to the switchboard was on.
  - Flow Line was Frozen
- Lost the race, top of the check valve was launched (into low earth orbit).
  - Decision to park upwind of the wellhead was reinforced and never forgotten. Company Man was not as fortunate.
- Gusher exceeded rig crown and relentless SW Wyoming wind distributed Ten Sleep crude over a large expanse.
- FORTUNATELLY NO INJURIES

Example 2

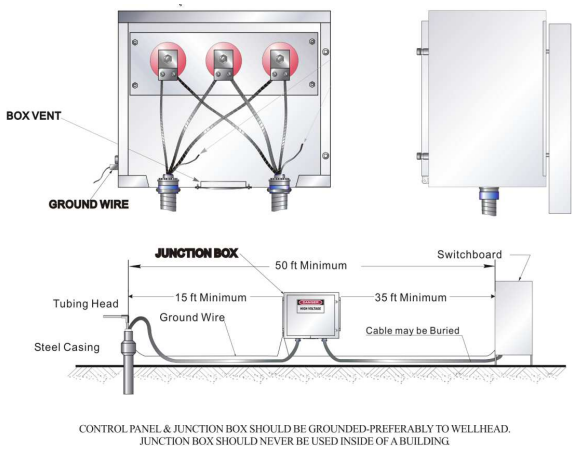
- Independent Operator
  - South East New Mexico
  - ~ 2011
- Startup of a new ESP installation
- Flow Line was blocked
- ESP FS Tech was near the wellhead timing pump up (fluid arrival at surface).
- Pumping Tee was malleable iron
  - merchant grade / 150# class / noncritical applications / hardware store
- Pumping Tee ruptured.
  - FS Tech was 26 and engaged to be married
  - FS Tech is now blind and suffered traumatic brain injury
- The live of many were changed forever, **It DOES Happen.**

Wellhead / Flowline Pressure Ratings

- Understand the maximum potential flowline pressure at **WORST CASE** Dead Head condition.
- Review prestart punch lists and startup procedures.
- Potential Mitigations
  - Walk down at flowlines, valves, fittings and consider pressure testing.
  - Surface equipment pressure rating
  - Pressure relief or Rupture pin valves
  - High pressure shutdown switches
    - Verify function before the startup
  - Regular function testing of shutdown / relief devices
- Training and awareness of employees

Vented Junction Boxes

- Flammable Gas
  - **is present** in most oil well applications
  - **may be present** in water source / water supply wells
- ESP power cable UNLESS VENTED provides a potential flow path from the annulus into the switchgear
  - Discussion on wellhead penetrators in 3 slides
- Provides a convenient and safe point to connect the well cable to the surface equipment



"API" Wellhead and Penetrator

- Available in ratings up to…
  - 10k psi
  - 8 kV
  - 280 Amp
  - Certification for use in classified locations available
  - Multiple manufacturers
  - Endless configurations and options
  - **STILL Consider** the installation of a vented junction box.

Examples

Eample 1

- FS tech (I know and worked with) in the Big Horn Basin of Wyoming starting an ESP in a Water Supply Well
  - Gas had migrated into the switchboard
  - Contactor closing arc ignited the gas, switchboard door separated from the cabinet and struck the tech
  - Extensive reconstructive surgery required head and jaw
  - Tech did recover (in time) and returned to work

Example 2

- FS tech (I know and worked with) on a DST offshore Kuwait
  - Gas had migrated into the switchboard
  - Contactor closing arc ignited the gas, switchboard door separated from the cabinet and struck the tech
  - Tech was transported to a Kuwait hospital and remained there for ~ 4 weeks before being transferred on to the UK for additional medical care

Summary

- Flammable gas may be present even in fresh water and brine wells
  - It may not be common, but it is possible
- A vented junction box is recommended on all ESP installations
  - While rare, there have been instances of wellhead penetrators "leaking"
- I NEVER stand in front of any electrical switchgear when it is energized, or a load applied
  - At a minimum wear safety glasses, FR level 1 clothing, stand to one side and look away when the start circuit is closed

"Independent" Wellhead - With Penetrator

- An improvement over the previous wellhead with no penetrator
- Slips, bottom plates, packoff rubbers and top plates replaced with a tubing hanger and penetrator
- Rated to 1.5k psi or 3k psi
- Not practical to nipple up a BOP to they wellhead

- **Vented Junction Box is still RECOMMENDED.**

ESP Lifting Equipment

- All lifting equipment should be carefully inspected BEFORE use
- All lifting equipment should have a unique serial number permanently attached
- All lifting equipment should be in a documented formal schedule to be inspected, load tested and certified as safe
- The service supplier representative should have copies of the current inspection certificates on site and available for viewing
- Tack welding of bolts to the clamp body is discouraged
- Fasteners should be Grade 8

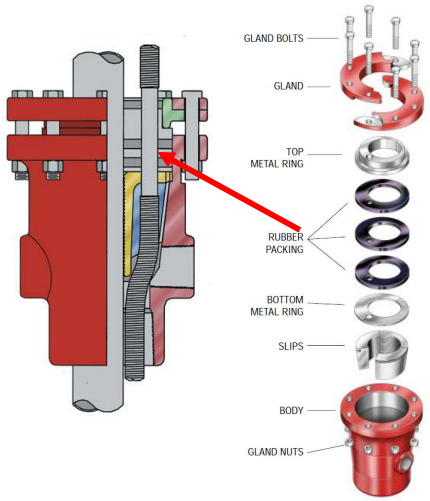
ESP Lifting Equipment

- It is common for ESP lifting equipment / tackle…
  - Equipment lifting clamps
  - Clamp slings (chain or wire rope)
  - Cable Sheave
    - Axle and other hardware
    - Suspension slings (hopefully Qty 2 which are attached at 2 different points)

…..to have been in service for decades

"Independent" Wellhead - No Penetrator

- Not appropriate for…
  - UR Wells
  - Wells in environmentally sensitive areas
  - When pressure control during an intervention is a concern
  - When a BOP must be nippled up
- However, still the standard in many regions when annulus pressures are low.
  - Water flood
  - Natural water drive
  - Depleted reservoirs
  - Water supply wells
- Packoff / seals directly on the cable jacket(s).
- **Vented Junction Box is REQUIRED.**



ESP Lifting Equipment

- It is not appropriate to further detail the on-site inspection procedures in this seminar
- The recommendation is that you request a copy of the service suppliers on site inspection procedure, spot check the on-site inspection and certifications
- Finally, remember the Qty 2 cable sheave suspension slings?
  - They slings should have separate points of attachment to the sheave
  - The slings should be attached to the rig structure at separate points

Cable Spooler Controls on the Rig Floor

- Controls located within a 10-foot radius of the wellhead must be rated for Class 1, Division 2 service
- Control Cable must be SOW, SOOW, STOW or STOOW (Extra Hard Usage, Wet Locations and Oil Resistant)
  - Also designed to minimize the transmission of gases and vapors through the cord
- The entire length must meet the SOW, SOOW, STOW or STOOW class standards
- A four (4) conductor cord is required.
  - One conductor for the common power feed (1)
  - Two conductors for Forward (1) and Reverse (1)
  - One required for Ground (1)
- A cord grip and connector rated for Class I Division 2 is required at the power cable x spooler control connection.

Electrical Area Classification

Class 1 Division 1 Location

- A location in which ignitable concentrations of flammable gases or vapors are expected to exist under normal operating conditions or in which faulty operation of equipment or processes might simultaneously release flammable gases or vapors and also cause failure of electrical equipment

Class 1, Division 2 Location

- A location in which flammable gases or vapors may be present, but normally are confined within closed systems; are prevented from accumulating by adequate ventilation; or the location is adjacent to a Division 1 location from which ignitable concentrations might occasionally be communicated.

Do you consider your rig floor a Div 1 or a Div 2 location?

Does it matter?

In either case the risk of flammable gas or vapor is present during work over operations.

Would you allow open flame, smoking etc. on the rig floor?

Additional Information

- Additional Reference Material
  - API 500 - Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2
  - NEC (National Electrical Code) / NFPA 70
  - EEE 1349-2011
- **Request assistance from a licensed electrican or other qualified person if you have questions or concerns.**

Equipment Details

EXPLOSION PROOF [redacted]

Medium Duty

Product ID:	Environmental Ratings:
[redacted]	CLASS I, DIVISION 1, Group D CLASS II, DIVISION 1, Group F & G CLASS I, ZONE 1, Group IIA NEMA Type 2, 3, 4, 6, 6P, 13, 7D & 9F UL ENCLOSURE 2, 3, 4, 6, 6P, 13, 7 & 9 EN 60529 Degree of Protection IP68 Meets IEC 60601-2-2 Driptight - Dusttight - Watertight - Oiltight

Power Cord Lettering Breakdown

- **S** = Extra hard service (rated for 600V)
- **J** = Junior (hard) service (rated for 300V)
- **V** = Vacuum cord (rated for 300V)
- **P** = Parallel cord
- **E** = Elastomer jacket (UL or NEC only)
- **T** = Thermoplastic jacket
- **O** = Oil resistant outer jacket
- **OO** = Oil-resistant outer jacket and inner insulation
- **W** = Weather and water-resistant - outdoor rated (note: this is NOT the same as Type W, another kind of portable cord)

Features

- Nylon Fitting
- Stainless steel mesh is corrosion resistant
- Neoprene bushing is oil and watertight

Ordering Information

Description	Form Size	Cable	UPC	Catalog Number
Nylon Fittings and Mesh, Straight Male Thread	F2	.187"-.250" (.47-.63)	783585335025	**CG404NM**

Listings

UL Listed
CSA Certified

Specifications

Strand	Non-metal
Fittings	Nylon

Performance

Environmental	
Flammability	UL 94HB (Strand grip), UL 94V-2(Fitting)
Hazardous Locations	Suitable for use in hazardous locations per Class I Div. 2, Class II Div. 1 & 2, Class III Div. 1 & 2 N.E.C
Operating Temperatures	–30°F to +225°F (–34°C to +107°C)
Wet Locations	Suitable for use in wet locations when used with a listed sealing ring between box and fitting

ESP Safety – Permanent Magnet Motors

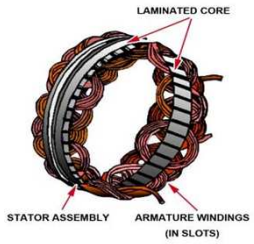
Dennis Harris
WPO and ALS Advisor
Chevron Technical Center

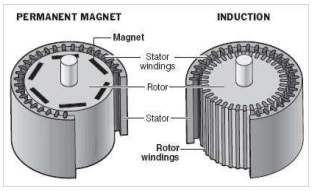
ESP Safety – Permanent Magnet

Topics in this presentation

A. What is a Permanent Magnet Motor (PMM) for ESP?
B. Two sources of power
C. Job planning: Risk identification and mitigation
D. On location

Permanent Magnet Motor (PMM) Safety





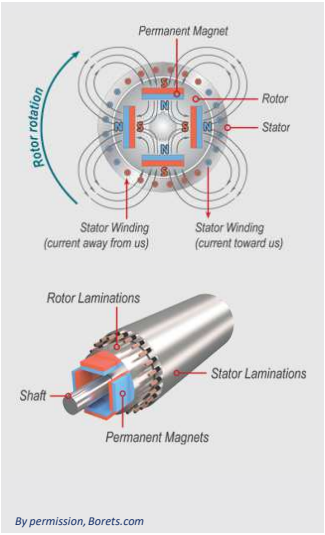
Images New Energy and Fuel.com (February 9, 2010) published in Empowering Powering Pumps, January 23,2017.

What is a PMM?

PMM & IM stators are the same:

- 3-phase armature winding which generates rotating magnetic field.
- Housings, heads, bases, and shafts the same or similar

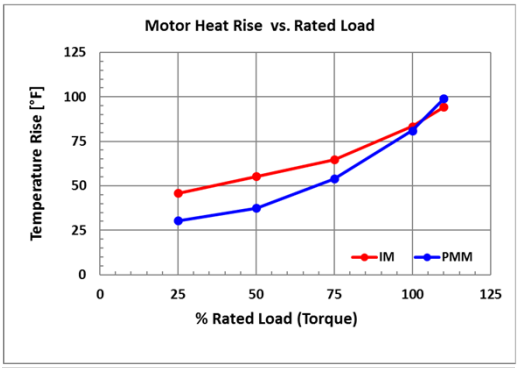
- Rare Earth Magnets replace the copper rotor bars in the rotor.
- (Neodymium or Samarium-Cobalt)
- Synchronous speed (no slip).
- VFD required to know the position of the magnets relative to the stator for alignment of the magnetic fields.



Permanent Magnet vs. Induction

Property	PMM vs IM
Length	**-25%**
Volume	**-25%**
Weight	**-33%**
Density	-9%
Poles (PMM, IM)	4 vs. 2
Rated Frequency, Hz	120 vs. 60
Rated Speed, rpm	3600 vs. 3484
Slip (PMM, IM)	0% vs. 2%

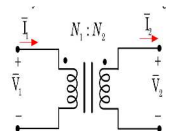
Property	Rated	Range
Rated Voltage	+ 11%	+8%
Rated Current	**- 14%**	-19%
Rated Heat Rise	- 13%	-13%
Rated Torque	+ 8%	+8%
Rated Power	+ 12%	+14%
Rated Efficiency	**+6%**	+ 8%
Rated Power Factor	**+14%**	+ 23%
Electrical Savings* * Operating Window	**+ 10%**	+18%

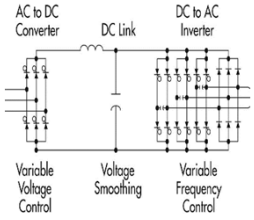


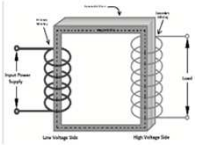
The difference is the rotor …
< copper < resistance, < heat rise, → longer life

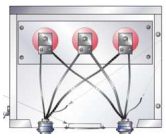
Source:
SPE-185129-MS Leveraging ESP Energy Efficiency with PMM; Harris, 2017

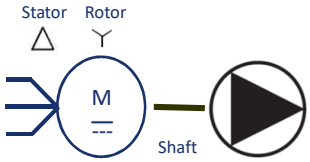
Conventional ESP (power on)











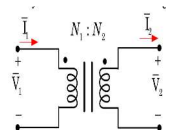
Power Consumption

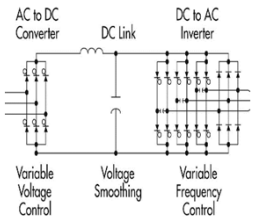
Primary Transformer | Variable Speed Drive | Step Up Transformer | Vented Junction Box | Electrical Submersible Motor | Centrifugal Pump

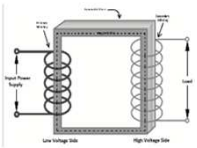
EMF is ON

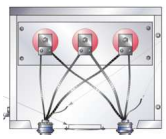
Work Performed. Pump rotates to lift fluids.

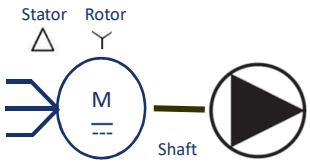
Conventional ESP (power off)











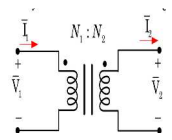
Power Consumption

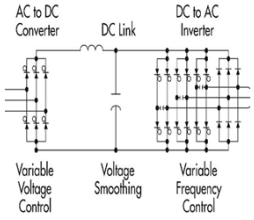
Primary Transformer | Variable Speed Drive | Step Up Transformer | Vented Junction Box | Electrical Submersible Motor | Centrifugal Pump

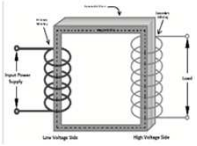
EMF is OFF

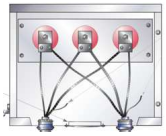
No work done

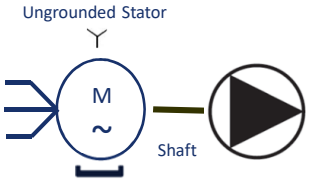
Permanent Magnet ESP (power on)











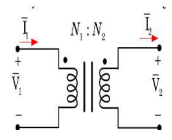
Power Consumption

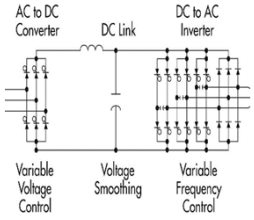
Primary Transformer → Variable Speed Drive → Step Up Transformer → Vented Junction Box → Electrical Submersible Motor → Centrifugal Pump

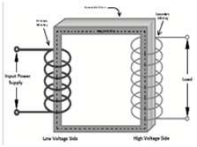
EMF is ON
MF is ON

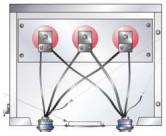
Work is done

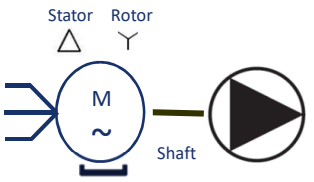
Permanent Magnet ESP (on or off ?)











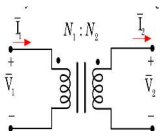
Primary Power Consumption

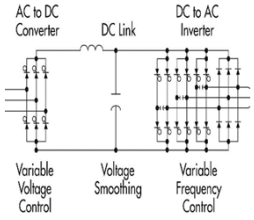
Primary Transformer → Variable Speed Drive → Step Up Transformer → Vented Junction Box → Electrical Submersible Motor → Centrifugal Pump

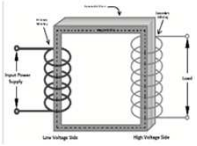
? ? ?

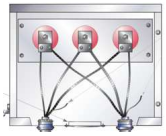
Permanent Magnet ESP (on or off ?)

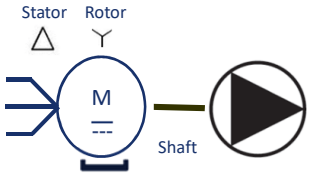
LOTO is performed, *are you safe?*











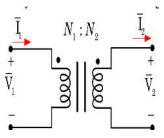
Potential Power Generation

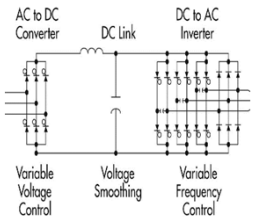
Primary Transformer → Variable Speed Drive → Step Up Transformer → Vented Junction Box → Electrical Submersible Motor → Centrifugal Pump

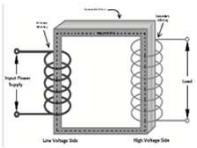
EMF may be off
MF is **ON**

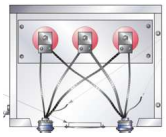
?

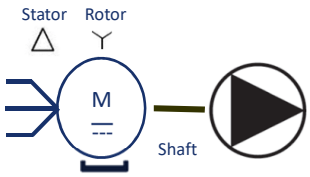
PMM in generative mode has the power to be lethal or severe injury !











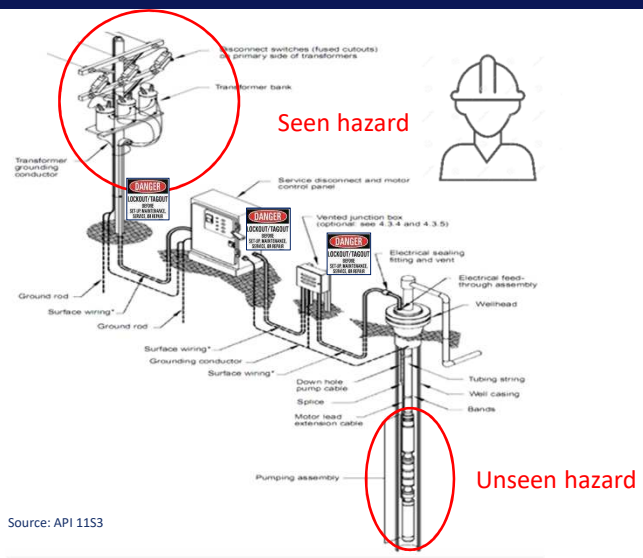
Secondary Power Generation **Pump rotates**

Primary Transformer → Variable Speed Drive → Step Up Transformer → Vented Junction Box → Electrical Submersible Motor → Centrifugal Pump

MF is **ON**
EMF is **ON**

Fluid Kick
Fluid Dump

Conclusion: PMM has 2 sources of energy



Primary: the grid

Secondary:

Well Kicks

Well Operations

- Fluid dumps
- Fluid injections
- Pulling of plugs,
- Opening sliding sleeves
- Opening diverter valves

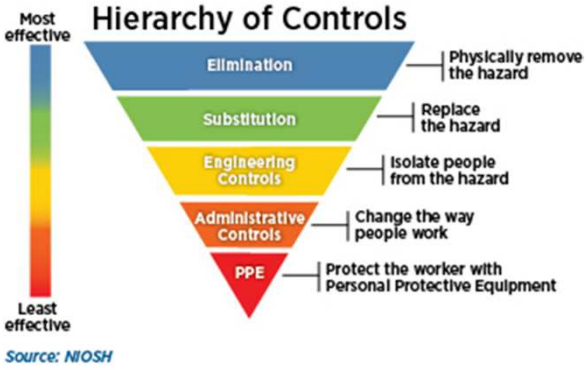
How can we manage the risk?

Administrative Controls:

- Lock-out/Tag-out
- Training and certification of personnel
- Regular Audits – Compliance verification
- Certification of equipment
- JSA/Risk assessment.
- Guidelines and procedures.
- Electrical grounding

PPE & Tools:

- Use task-suitable PPE.
- Use task-suitable tools & instrumentation.



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Mitigations: subsurface barriers

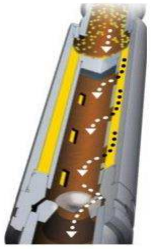
8. Well control - If the motor does not turn, it cannot generate electricity

- Presently not possible to physically lock the motor or pump shaft to prevent rotation, but it's being worked
- Never presume the downhole barrier devices are working, always test and pressure check
- 1 or more downhole barriers are beneficial. Example: rupture disc for RIH & diverter valve on POOH

Blanking plug

Diverter Valves rupture disc or retrievable

Sliding Sleeves



Various Ball Devices: check valves, Ball plugs, Standing valves, et.

ESP Safety - Permanent Magnet

1. **Job Safety Planning** - Everyone working with PMM technology has potential hazardous or fatal risk and must be informed.
   - PMM type ESP look exactly like induction motor ESP on the outside, but inside very different
   - The voltage level depends on the rotating speed
   - Field personnel are not accustomed to the two potential energy sources

2. **PMM can be used safely.** **Everyone can go home safe.**

ESP Safety - Permanent Magnet

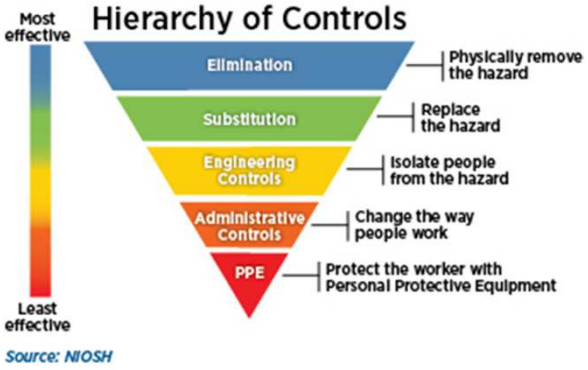
3. **While working with PMM a "no-access" zone shall be erected and include:**
   - Non-hazard work area, the spooler, and wellhead with clear line of sight to the spooler. Offshore operations may vary due to the space limitations. Bright color tape may be used.
   - Hazardous work area is the wellbore vicinity (~5 ft radius) in which hazardous gases could explode if sparking resulted from PMM in a generative mode due to unplanned rotation.
4. **No simultaneous operations (Simops) in that wellbore shall be performed.**
   There must be a well spotter to the PMM technician who ensures no simops are performed and shall not perform other duties while spotting for the pmm technician at work. Further, this spotter has Stop Work Authority for the hazard and non-hazard work areas related to PMM.
5. **Only a task qualified person(s) shall work with PMM.**
   a person who by a combination of documented supervised training and practical experience has demonstrated competency to perform specific electrical tasks. This person must be certified in the knowledge of PMM including safety equipment, tools, and instruments rated for the potential hazard following all local and national electrical codes.

Job planning is how to manage risk

Elimination:
- No simultaneous operations.
- Inspection & Test

Substitution:
- Run IM if MOC inadequate.

Engineering Controls:
- Access barriers
- Distancing around energized systems, remote read-out & non-contact instruments
- Warning labels/signs/signals/equipment marking
- Use of continuous monitoring devices.
- Use of Shorting Box and Blocking Caps
- Test Meters
- Downhole barriers to prevent unplanned motor rotation



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Permanent Magnet Motor Safety
API RP 11S9

-29-20

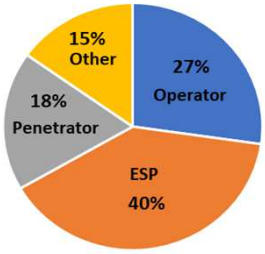
American Petroleum Institute

Recommended Practice 11S9, 1st Edition , 2022

Mission:
To ensure every worker in the oil industry involved with Permanent Magnet Motor artificial lift technologies goes home safely for both subsurface electrical submersible pumps and surface artificial lift.

Vision:
To publish a minimum safety standard in the American Petroleum Institute (API) and promote safety awareness among users, vendors or service providers with agencies and publications such as the Society of Petroleum Engineers (SPE) and trade journals such as World Oil and to expand out to the water well industry.

33 companies
40+ professionals



Update: API ballot passed 6/30/2022 and is now in process of publication.

ESP Safety - Permanent Magnet

6. Installation, operations and troubleshooting

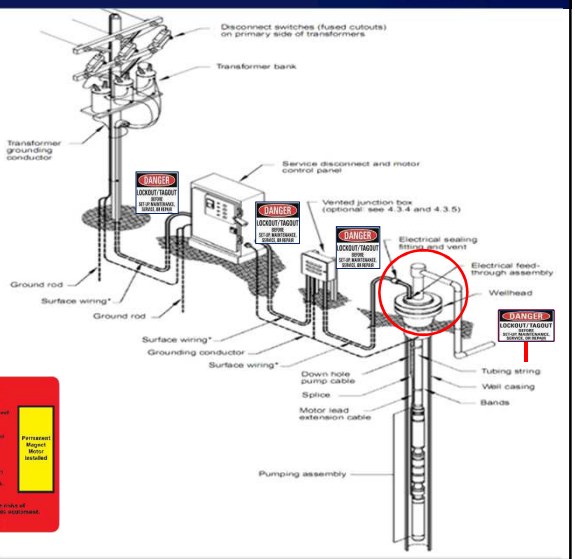
- Be aware a generative circuit does not end at the surface necessarily; a damaged cable may move the circuit below the wellhead ground point out of view.
- Ground to an approved grounding point
- Ensure spoolers are insulated, shorted & grounded, or shorted & isolated
- Be alert involving cable cutting, splicing, and penetrator work.
  This work only to be done in the non-hazardous zone.
  If not possible, then gases and voltage need to be monitored.
- Watch trip speed in and out of hole. (discuss in Job Safety Planning and JSA.)
- Only task qualified persons should access an ESP "L-Box" surface conduit or penetrator caps at the wellhead. Service crews are not permitted to lift the wellhead until cleared.

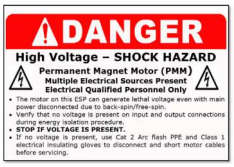
Penetrator caps
& feed throughs

Spoolers

ESP Safety - Permanent Magnet

7. **Signage**
   - Large enough to stand out from all the other normal electrical hazard signs . Color should be unique





ESP Safety - Permanent Magnet

Temporary signage may solve the immediate, but….

often forgotten about in the follow up, and …

it can disappear or not be seen.

People become exposed to an otherwise preventable risk.

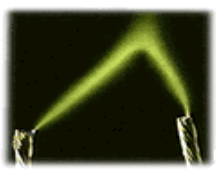
If no signage … assume every ESP well has a PMM !

ESP Safety – Permanent Magnet Motors

Walter Dinkins
Sr. Domain Champion
Borets USA

Why is Electricity a Hazard?

- Danger to Personnel & Equipment
- Five primary hazards of electricity are:
  - Shocks
  - Burns
  - Arc-Blast
  - Explosions
  - Electrical Fires



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Training & Certification

Personnel:

Task Qualified Person is… **electrically qualified, PMM competent,** and **certified** for PMM **work**

- Trained by PMM SME who is certified. Must pass knowledge exam or pass field Service training school. To include, Electrically Qualified Worker Training, NFPA 70E, Arc Flash, and LOTO
- For EQWs in training, it is recommended they serve as an "Assistant" under the supervision of qualified PMM competent Electrically Qualified Worker
- First Aid Training
- Be able to conduct a PMM related JSAs and able to identify all associated risks
- Regular Audit for compliance verification

PPE & Tooling:

- All PPE & Tooling to be certified / calibrated as per manufacturer's recommendation and as per a defined schedule that is regularly maintained and subject to audit
- To be inspected before conducting on site work

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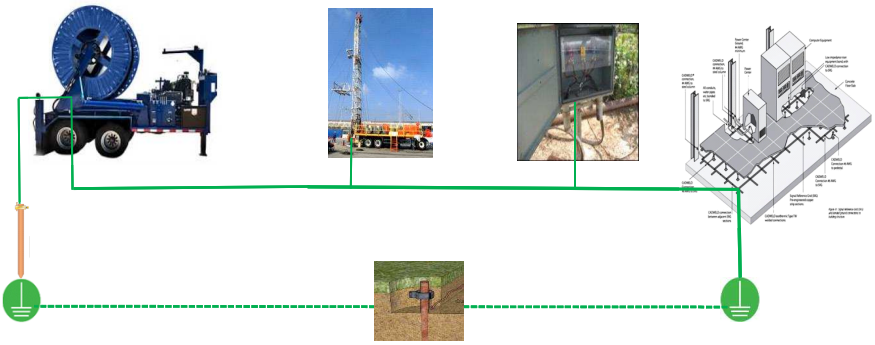
Engineering Controls

Lock Out – Tag Out (LOTO):

- LOTO Protocol must be in place and documented in Job Safety Analysis (JSA)
- LOTO should take place at Electrical Service Utility Main Breaker, VSD, Junction Box, or Cable End Termination prior to commencing any operations

Administrative Controls

Electrical Grounding



- Check ground continuity. Cable spooler must be grounded and connected to wellhead. Always maintain a physical connection between wellhead and vent box. use an external cable if required
- Ensure cable spooler and rig are properly grounded. **Ground resistance should be less than 10 Ohms. Check should be performed before scheduling rig move**

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Risk Management – PPE & Tooling

Personal Protective Equipment (PPE):

- **Minimum Required PPE**:

- Face – Arc Flash Face Shield, Cat 2

- Fire Resistant Clothing, Cat 2

- Hands – Dielectric Lineman Gloves with Leather Outer rated to 17KV Class 2 (Test voltage: 20 KV, Thickness: 2.3 mm, Label Color: Yellow)

- Feet – Non Conductive Safety Toed Footwear with Electrical Hazard (EH) designation

- Ground – Non Conductive Insulating Matting, Class 2 17KV Generic Foam protective carpet

PPE & Tooling

PMM Recommended Tooling

- Crimping Tool with Insulated Handles

- Shearing Tool with Insulated Handles (Hydraulic shear for round cables)

- Fluke AC3001

- Grounding / Shorting Box

- 5000 Digi Voltmeter

- Digital Clamp Meter

- Digital Multi-Meter

- PT500 Voltmeter Proof Tester

- Hot Sticks 2ft. Length x2

- Grounding Alligator Clips

- Grounding / Shorting Lug with Insulating Cap Protector

- Grounding / Shorting Lug Lockout Box with Key Pad and Lock

Risk Management – Example

PPE & Tooling

A Field Service Technician checking the cable at the Shorting Box in full PPE and using designated tooling

- Insulating nonconductive mat
- Clothing
- Face shield with neck wrap
- HV rated gloves & leathers
- Probe / instruments

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Operational – RIH

- Conduct pre-job safety meeting with ALL personnel on wellsite location
- PMM qualified and trained FS Technicians are **only** allowed to perform the job. This includes removing the penetrator cap before rig crews nipple down the wellhead and pull the first joint of tubing.
- All required PPE should be used as per Vendor PPE standard
- **NO SIMOPS**
- Follow standard PMM provider procedure for installing MLE to motor
- Use insulation tape to isolate cable end conductors inside the reel. This will minimize the risk of getting a spark between conductors and reel during RIH
- Install each leg into cable grounding / shorting box and firmly secure each lug on terminal strip. Prior to installing Motor Lead Extension (MLE) to motor, verify all cable leads are shorted together at grounding / shorting box
- Check Motor + Cable P-G resistance from shorting box on cable reel which should read 1000 Mohm at least. **Note:** cable P-P readings are to be checked prior to installing the shorting box. Check downhole sensor readings

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Operational - RIH

- Verify zero voltage is present on cable
- Prior to POOH or RIH, record readings of downhole sensor for all parameters (if applicable), as well as cable insulation resistance phase-ground (P-G) and phase to phase (P-P) values
- Install each leg into cable grounding / shorting box and firmly secure each lug on terminal strip
- Close grounding /shorting box door and ensure it is secured to cable reel
- Continue to take P-G readings through grounding / shorting box as per customer requirement or every 1000ft.
- P-P readings are to be taken only at the beginning of installation and/or pull & once unit has landed, and cable removed from grounding / shorting box

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Operational – RIH splice

- Class II high voltage gloves, face shield, Fire resistant clothing, EH safety toed footwear and electrical safety mats should be used to perform any electrical tests at wellsite. If megger test or downhole sensor reading checks are required during RIH, confirm no voltage present at the shorting box using 5000 V Digi-Meter and appropriate PPE.
  Do not perform any electrical measurements if voltage is not zero.
- If a cable splice is required or while running cable through wellhead, confirm no voltage is present at the shorting box using the shorting box using 5000 V Digi-Meter and appropriate PPE and appropriate PPE (shorting block).
- Always check for presence of voltage in cable using a non-contact high-voltage AC detector or a 5000 V Digi-Meter. Always isolate cable leads. Only PMM qualified and trained personnel are allowed to perform splicing

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Operational Procedure – Wellhead

PMM wellhead termination

There are numerous types of cable connector and wellhead feedthrough systems employed in ESP installations. It is important to refer to each specific vendor's installation procedure prior to assembling any connector or feedthrough. Always check and monitor for zero voltage prior to commencing with any connector or feedthrough assembly and installation.

- Verify zero voltage by measuring on motor / downhole side of cable
- Connect penetrator / feedthrough to cable according to specific connector manufacturer's guide
- Verify zero voltage by measuring through connector
- Attach lower connector to penetrator / mandrel
- Land tubing hanger
- Verify zero voltage by measuring through penetrator / mandrel
- Attach surface connector or cable to penetrator / mandrel
- Label wellhead connection with hazard identification signage to indicate a PMM is in use downhole and an electric shock hazard could be present even when system is locked out and not energized

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Operational Procedure - Startup

Surface Equipment Preparation & Start-Up

- Class II high voltage gloves and electrical safety mats should be used to perform any electrical tests at wellsite. If megger test or downhole sensor reading checks are required before connecting downhole cable to JB, SU Transformer and VSD, confirm no voltage is present in shorted cable leads using a 5000 V Digi-Meter and appropriate PPE. **Do not start any electrical measurements if both the current and voltage are not zero**
- Perform start-up as per procedure
- Label all surface equipment and switch gear with hazard identification signage to indicate a PMM is in use downhole and an electric shock hazard could be present even when the system is locked out and not energized




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Operational Procedure - Startup

Surface Equipment Preparation & Start-Up

- Conduct pre-job safety meeting with involved personnel
- Discuss and review all risks involved in PMM operation with rig personnel and all involved personnel
- PMM qualified and trained FS Specialists are only allowed to perform the job
- All required PPE should be used as per PPE standard
- Safety barriers should be installed around surface equipment and access restricted only to authorized personnel
- Safety barriers may also include cones, tape and signage
- Check ground continuity. Surface equipment must be grounded. Ground resistance should be less than 10 Ohms
- Ensure ESP cable conductors are shorted and isolated
- Verify zero voltage by measuring downhole cable end before connecting to Junction Box, SU Transformer and VSD

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Operational Procedure - PULL

PMM POOH

- Obtain site authorization & conduct pre-job safety meeting with involved personnel
- Discuss and review all risks involved in PMM operation with rig personnel and all involved personnel
- PMM qualified and trained FS Specialists are **only** allowed to perform the job
- All required PPE should be used as per PPE standard
- Pre-Pull surface preparation, Spooler positioning and set-up
- Verify zero voltage is present at J.Box, surface cable, or penetrator / feedthrough
- Disconnect surface cable at wellhead
- Verify zero voltage at penetrator / feedthrough
- Hoist tubing and disconnect connector from penetrator / feedthrough located in tubing hanger or cut cable below tubing hanger as required using manual shears with insulated handles or pneumatic shears.

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Operational Procedure - PULL

PMM POOH (continued)

- Verify zero voltage is present on cable
- On downhole or motor side cable, install grounding / shorting lug cap connector with each cable leg secured and cover with insulating cap protector
- Apply di-electric tape to secure insulating cap protector to cable armor
- Route cable through sheave and cable reel slot at spooler
- Remove insulating cap protector and grounding / shorting lug cap from cable and verify zero voltage is present at cable
- Prepare cable for pulling and secure to grounding / shorting box at cable reel

- Change out the reel once it has reached capacity limit

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Questions and Comments

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