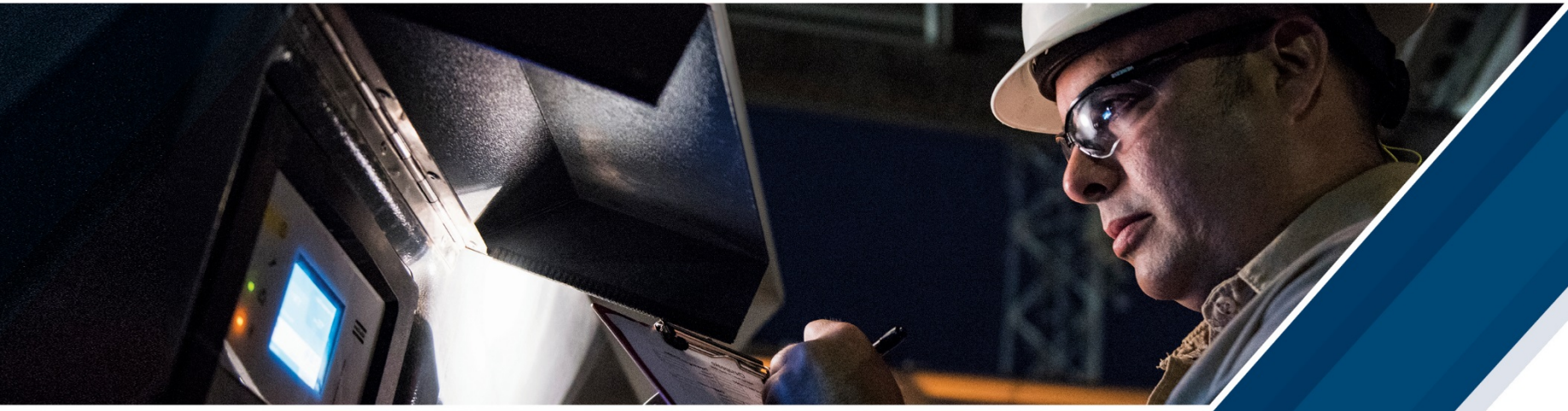
ADVANCED MANUFACTURING OFFICE – DEPARTMENT OF ENERGY
CLEAN WATER PROCESSING TECHNOLOGY R & D

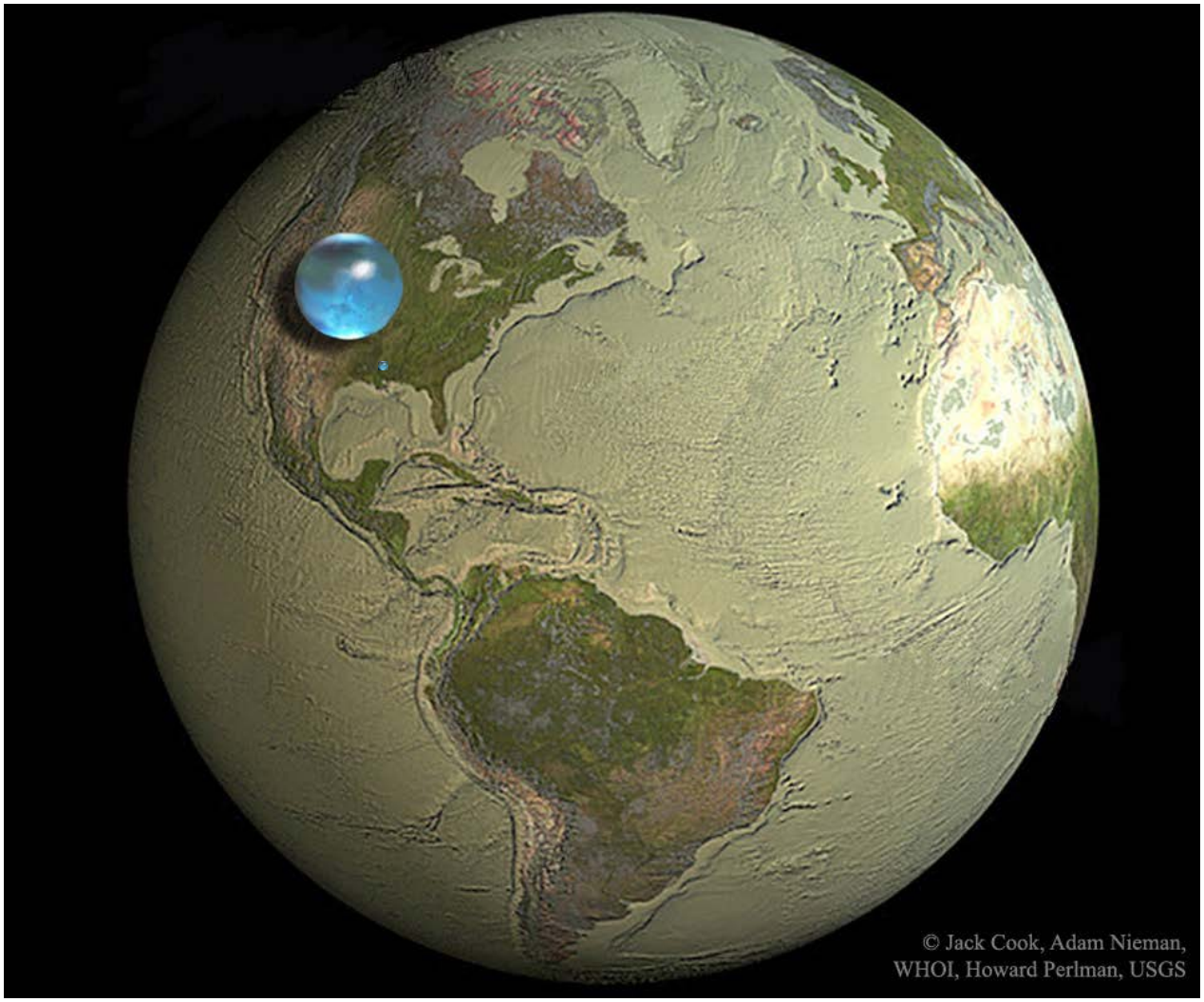


Produced Water Treatment – A Look at Current Technologies, Challenges and Opportunities

Rick McCurdy – July 10, 2017

CHESAPEAKE ENERGY

BUT FIRST



AGENDA

- Current Technologies and a Few Known Issues
- Promising Technologies on the Horizon
- Hindrances to Beneficial Reuse

Photo courtesy of Rick McCurdy

Current Technologies and a Few Known Issues

- ECONOMICS
- POWER DEMAND
- WASTE / PRODUCT GENERATION

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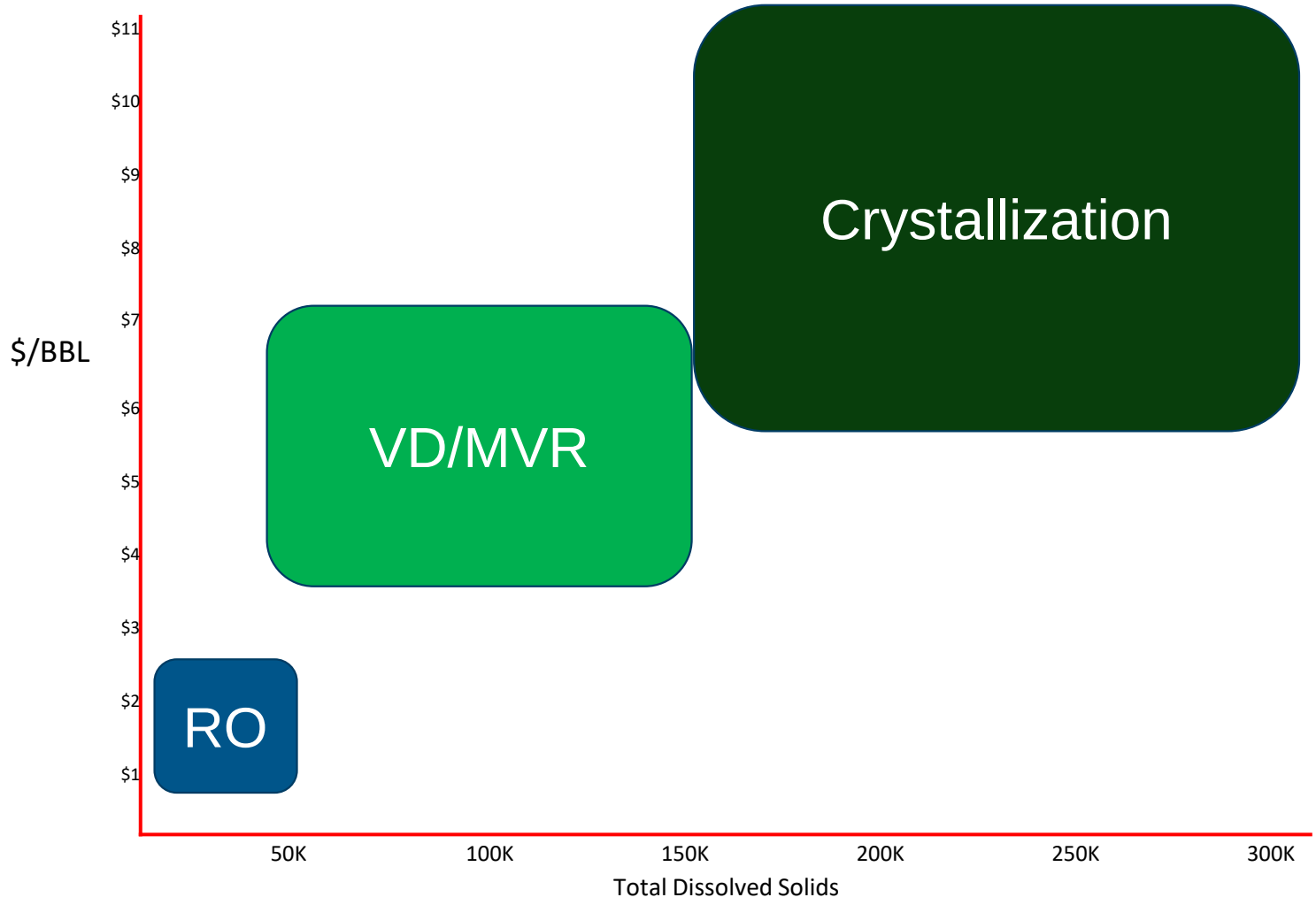
ECONOMICS


$/BBL
$11
$10
$9
$8
$7
$6
$5
$4
$3
$2
$1
Crystallization
VD/MVR
RO
50K
100K
150K
200K
250K
300K
Total Dissolved Solids

POWER DEMAND

Photo copyright Forbes

- VD/MVR & ZLD plants typically need 6-8 kwh / bbl water processed
- 50,000 bpd plant would use 109.5-146.0 gwh/year
- Avg household consumption is 10,932 kwh/year[1]
- Avg household in Oklahoma has 2.55 people[2]
- A single 50,000 bpd plant will have the energy demand of a city with a population of 25,000-34,000 people!

1 – U.S Energy Information Administration (2014)
2 – U.S. Census 2010

WASTE / PRODUCT GENERATION

Capacity		Products and waste			
bbl/day	MGD	Filter Cake, (tons/day)	Distillate, (bbl/day)	Salt (tons/day)	$CaCl_2$ Brine (bbl/day)
5,000	0.2	53	4,000	107	1,000
50,000	2.1	533	40,000	1,066	10,000
100,000	4.2	1,066	80,000	2,132	20,000
200,000	8.4	2,132	160,000	4,264	40,000
300,000	12.5	3,198	240,000	6,396	60,000

Numbers based off of typical composition of a produced water that is relatively high in salinity with a moderate level of hardness.

Promising Technologies on the Horizon

- Acid - Base Generation
- Membrane Distillation
- Plasma Arc Generation

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ACID BASE GENERATION

- Pros
  - > Generate products regularly used by Oil and Gas industry
    - HCl, NaOH, biocide
  - > Plant easily expandable from 5,000-50,000 bpd
  - > Can co-operate with other brine-mining operations such as iodine extraction
- Cons
  - > Energy intensive (2-4 kwh per bbl treated)
  - > Market for generated products?
    - A small 5,000 bpd plant will produce:

      75,000 gal 15% HCl

      40,000 gal 25% NaOH

      10,000 gal oxidizing biocide

      EACH DAY!

MEMBRANE DISTILLATION

- Pros
  - > Membrane is resistant to fouling
    - only pretreatment is oil removal
    - Hardness and bacteria have not shown to be troublesome
  - > Low energy demand
  - > Can handle high TDS brines
  - > Can utilize waste heat sources
  - > Potential to provide recovery of a distillation unit at the cost of a reverse osmosis (RO) membrane
- Cons
  - > Oil can foul membranes
  - > While more economical than a VD/MVR process and much less energy intensive – still cannot compete with majority of Class II SWD options; however, waste heat can swing the pendulum

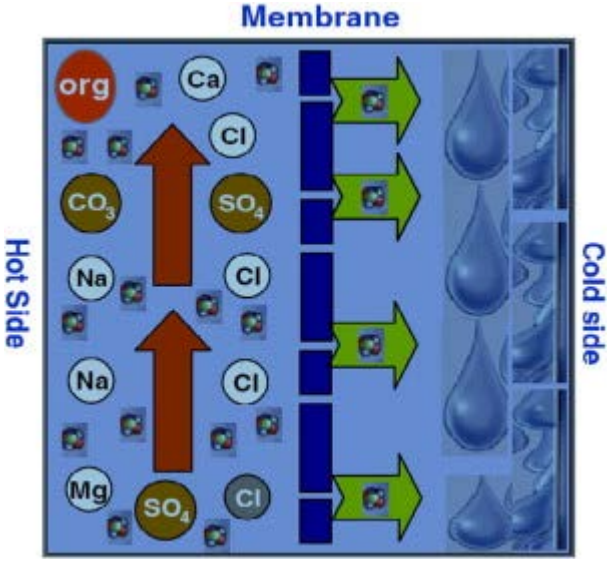

Illustration from Filter+Seperation.com

PLASMA ARC

- Pros
  - > Can handle any TDS water with minimal pretreatment requirements
  - > Mobile treatment units that can be installed at well pads
  - > Can process other waste streams as well
  - > Planned designs for systems from 1,500 – 10,000 bbl/day capacity
- Cons
  - > Insufficient data on air emissions
  - > Mineral scale deposition potential has not been fully vetted through field scale pilots
  - > Further data needed on value or disposal needs for generated solids
  - > Energy demand not vetted through field scale pilots

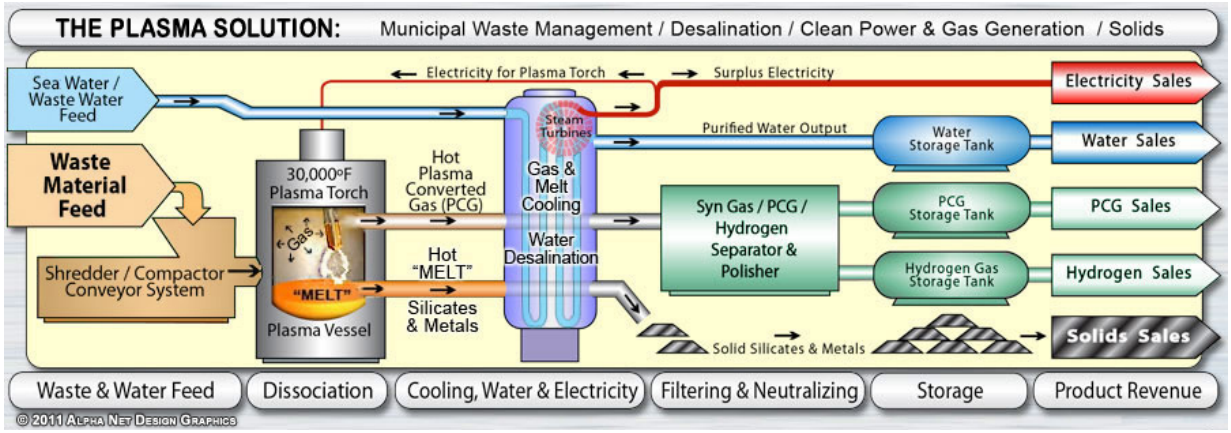

Illustration property of Alpha Net Design Graphics and found on ichaz.com

Hindrances to Beneficial Reuse

- **HOW WILL THE WATER BE USED?**
- **WHAT IS IN THE WATER?**
- **WHERE WILL IT BE USED?**

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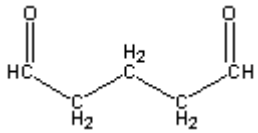
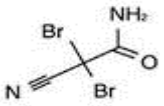
HOW WILL THE WATER BE USED?

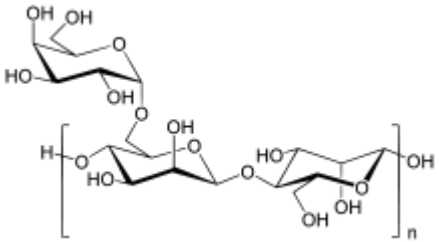
- Mined
  - > Basic mineral extraction (NaCl, $CaCl_2$, $BaSO_4$)
  - > Other possibilities (Iodine, Lithium, etc.)
- Feedstock
  - > Chlor-Alkali plant
- Agriculture
  - > Non-consumable plants (cotton, golf courses, etc.)
  - > Consumable, animal feed
  - > Consumable, human consumption
- Direct discharge
  - > Surface discharge
  - > Aquifer recharge

WHAT IS IN THE WATER?

- The brine itself or the treated distillate?
  - > Lack of analytical techniques for many organic compounds in high TDS matrix
  - > Focus on the treated fluid that would be intended for introduction into the environment
- Do we need to analyze for a thousand chemicals?
  - > If so, how many times and how often?
  - > What about surrogate families?
- How do we minimize waste streams?

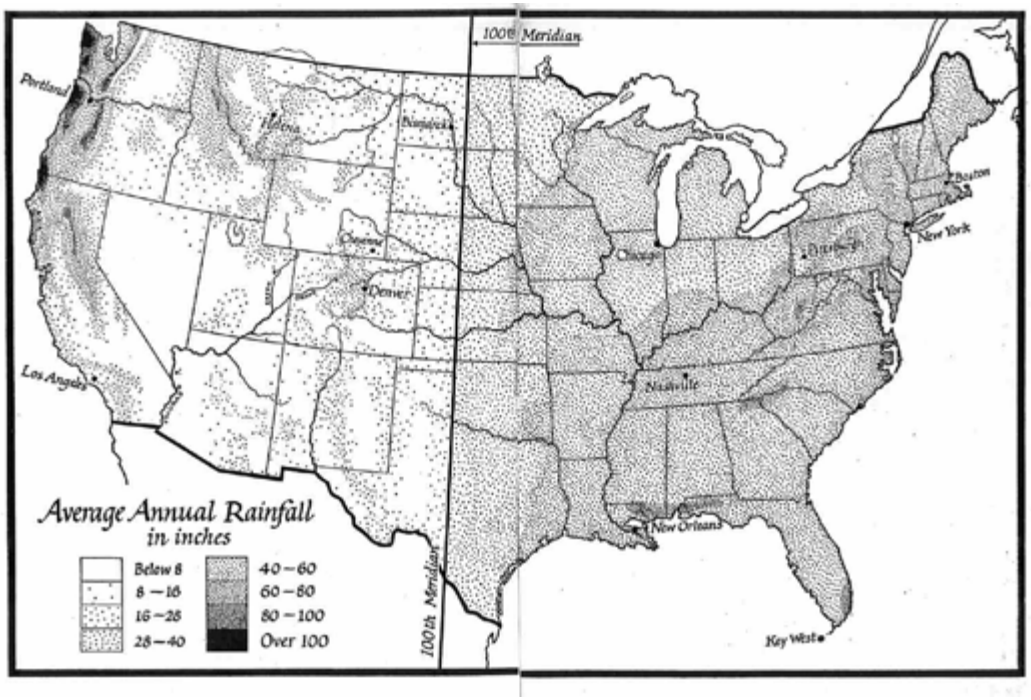






WHERE WILL IT BE USED?

- Location, location, location
  - > West of the 98th Meridian helps
  - > Does this need to be addressed?



Map courtesy of www.dailyyonder.com

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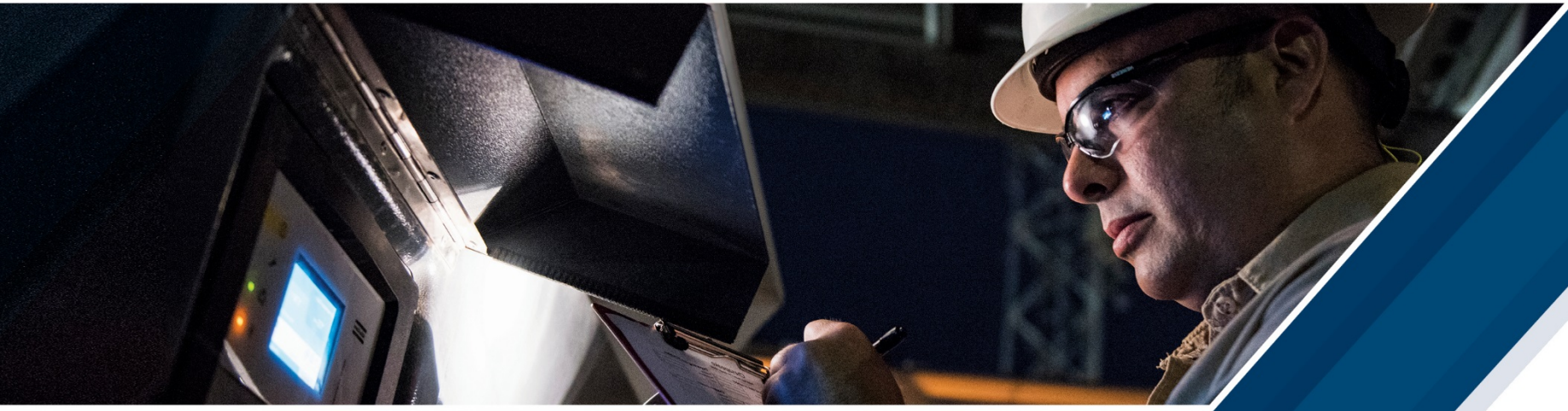

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