Paper 166118-MS
Design of a Cyclonic Solids Jetting Device and Slurry Transport System for Production Systems

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PRESENTATION OUTLINE

- Production Separator Sand Jetting
- Cyclonic Solids Jetting Device
  - Operating Principle
  - Shielded Vortex Sand Removal
  - Installation in Production Separators
  - Variables Affecting Sand Removal
  - Slurry Discharge Concentration
- Slurry Transportation
  - Erosion Velocity
  - Horizontal and Vertical Transport Velocity
  - Piping Design and Operation
- Slurry Dewatering and Disposal
  - Hydrocyclones, Filter Bags, and Filter Bins
- System Design

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PRODUCTION SEPARATOR SAND JETTING

- All oil and gas wells produce sand
- Exclusionary method – completions or maximum sand free rate
  - Equip. failure / completion limitations / production step-change
- Inclusionary method (SPE 164645)
  - Sand co-production → less skin → increased hydrocarbons
- Remove sand at wellhead prior to choke with wellhead desander
- Primary sand accumulation in production separator
  - Loss of residence time, corrosion enhancement, sediment in oil, increased oil in water, and degraded injectivity
- Production separator sand removal
  - Isolation and removal = production loss
  - On-line devices: spray jets/pans, conveyance sprays, vortex devices, and eductors
  - Cyclonic jetting device: low water usage with no interference in separator oil-water-gas disengagement

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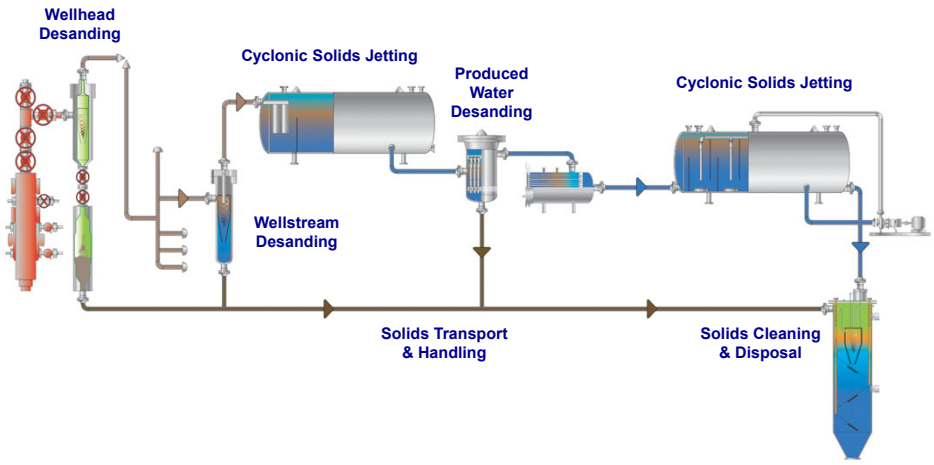
FACILTIES SAND MANAGEMENT



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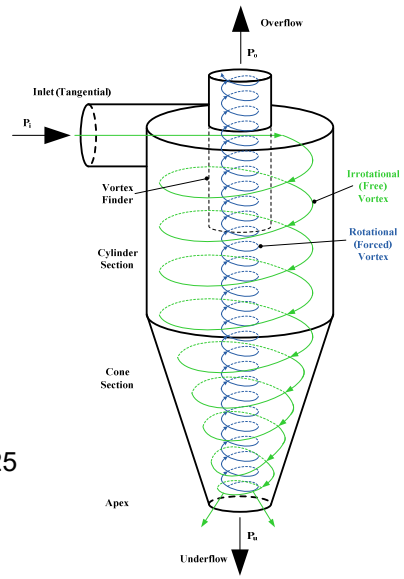
CYCLONIC SOLIDS JETTING DEVICE

Cyclonic Technology
- 1st patent 1891
- Standard unit process for separation, concentration, mixing, attrition, etc.
- Gas, liquid, or slurry streams
- Highest throughput-to-size ratio

Solid-Liquid Hydrocyclone
- Static device using fluid flow/pressure
- Geometric design creates helical flow
- Coupled free and forced vortex pattern
- Flow split (S) function of D_u/D_o and pressure differential ratio (PDR)
- Standard operation at PDR=1.0, S=0.25
- Overflow siphon introduced 1975 reducing S=0.10-0.15 (PDR=1.1-1.2)



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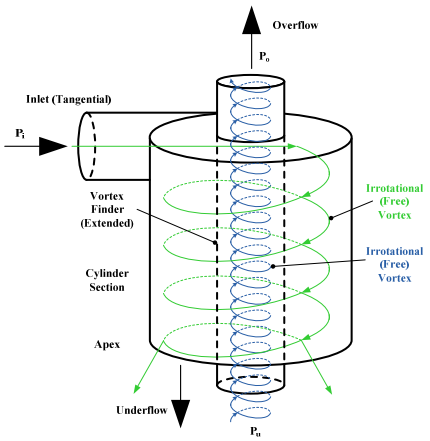
OPERATING PRINCIPLE

JEtting Cyclonic Technology (eJECT™)
- Truncated cone
- Extended vortex finder
- Uncoupled vortices
- Annular vortex fluidizes sand
- Center vortex captures sand
- PDR=1.3-1.5 to balance S
- Shielded vortex sand removal
- Prevents turbulence above solids removal zone
- Solids fluidized, captured, and transported



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SHIELDED VORTEX SAND REMOVAL

Video
(4:05-4:26)

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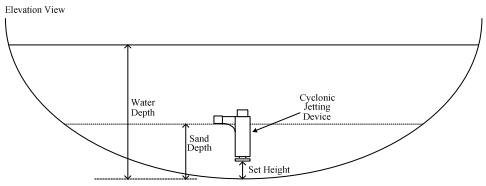
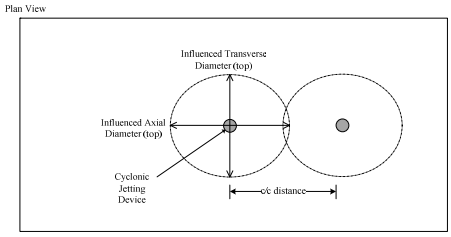
HORIZONTAL VESSEL INSTALLATION

- Small diameter (<2.0 m) vessel
- Single row along centerline
- Axial, vertical orientation
- Ellipse shape: axial w/ vessel
- Spaced c/c minimal overlap between major axes of ellipse

- Inlet connection: spray
- Outlet connection: slurry
- Aggregate four units





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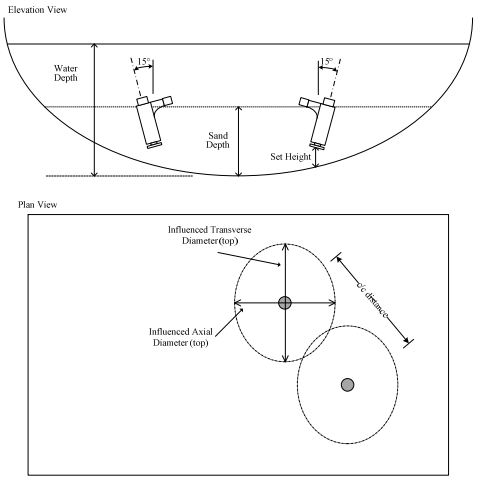
HORIZONTAL VESSEL INSTALLATION

- Large diameter (>2.0 m) vessel
- Double row straddle centerline
- 15° from vertical
- Ellipse shape: transverse w/ vessel
- Staggered spacing c/c minimal overlap between major/minor axes of ellipse

- Inlet connection: spray
- Outlet connection: slurry
- Aggregate four units



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OTHER VESSEL INSTALLATION

- Vertical vessels:
  - One unit for <1.5 m diameter
  - Multiple units for >1.5 m diameter
- Atmospheric tanks:
  - Requires eductor on slurry discharge for PDR
  - Line sized for eductor motive flow w/ slurry

- Instrumentation/Valves:
  - Spray: Pressure/Flow control valve
  - Slurry: PCV/FCV on outlet (after desanding cyclone)
  - Pressure instrumentation on both

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VARIABLES AFFECTING SAND REMOVAL

Total affected area indicates how much sand removed
Variables include:

- Set height: clearance below device
- Spray flow/pressure
- Slurry flow/pressure
- Sand depth
- Installation angle
- Particle density and size distribution

Affected area: top area of the influenced ellipse
Avg. affected diameter: mean value of major and minor ellipse axes

Optimum values achieved

- Area: 1.1 m² (11.7 ft²)
- Diameter: 120 cm (47 inch)

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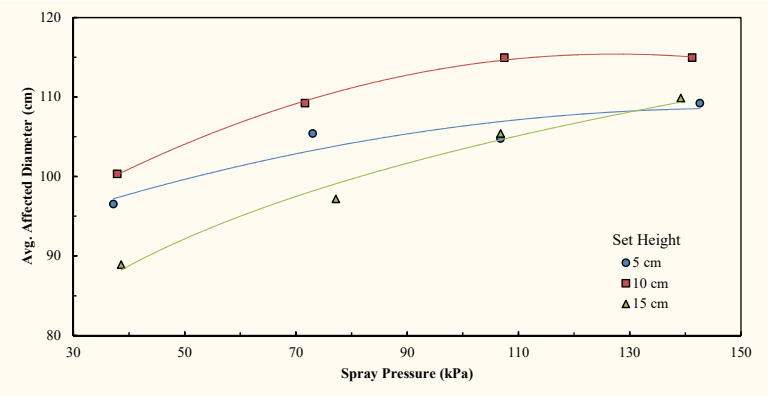
VARIABLES AFFECTING SAND REMOVAL: SPRAY PRESSURE AND SET HEIGHT



Single unit, 28 cm (11”) sand depth, 2.65 s.g. sand, D_{50}=420µm

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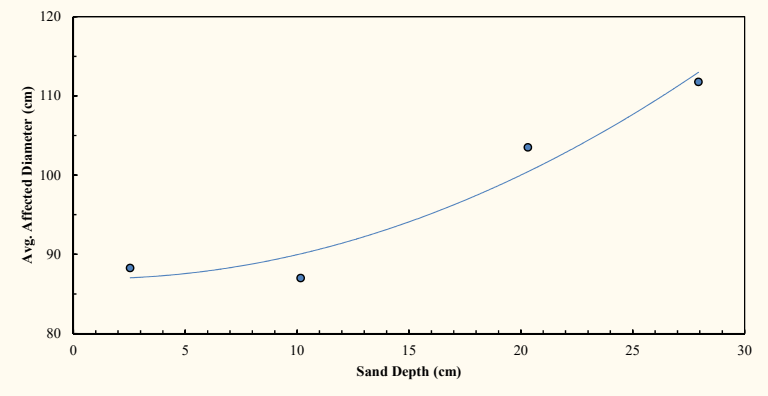
VARIABLES AFFECTING SAND REMOVAL: SAND DEPTH



Single unit, 10 cm (4”) set height, 110 kPa (15 psi) spray, same sand

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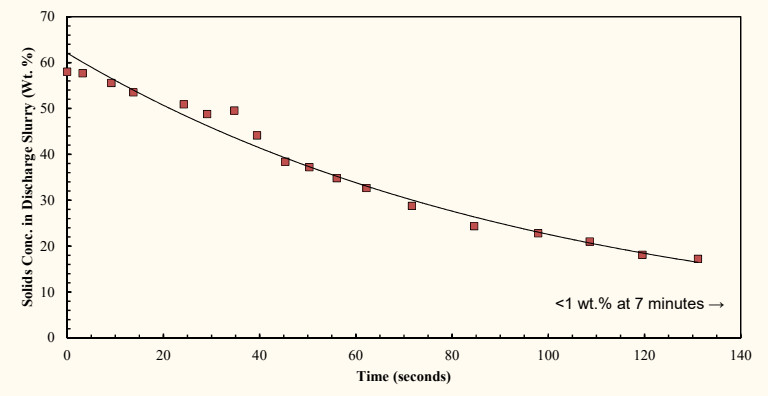
SLURRY DISCHARGE CONCENTRATION



Single unit, 10 cm (4”) set height, 28 cm (11”) sand depth, same sand

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SLURRY PIPING DESIGN

Erosion Velocity:
- API RP 14E: 3.7 m/s (12.2 ft/s)
- McLaury-Shirazi (SPE 56812): >30 m/s (>100 ft/s)
- 1” pipe for single unit, 2” for four units

Horizontal Transport Velocity:
- Minimum velocity with Durand-Wasp equation

$$V_{MT} = F_L[2gD(s-1)]^{0.5}\left(d_p/D\right)^{1/6}$$

- F_L=1.5, s=ρ_s/ρ_l, D=pipe ID, d_p=avg. particle size
- V_{MT} = 0.65 m/s (2.1 ft/s)

Vertical Transport Velocity:
- V_{MT}=2V_{Stokes} ~ 1440µm

Boundary Conditions: 0.65-3.7 m/s (2.1-12.2 ft/s)
Pipe use: 1-2 hours per day

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SLURRY PIPING DESIGN

General Design:
- ASME 31.11 for slurry piping transport systems
- Horizontal runs sloped
- Elbows at long radius or 5R/10R
- >10D between elbows
- Eccentric reducers
- Full port valves of gate or rotating disc
- Sample ports on vertical upflow only

General Operation:
- NEVER introduce slurry into empty piping or process equipment
- Pre-fill with (moving) water
- Post-flush all piping

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SLURRY DEWATERING AND DISPOSAL

Dewatering – removal of liquids associated with slurry
- >90% volume reduction
- Liquids returned to process

Keep system compact and simple – one or two step process
- Single 6” hydrocyclone for bulk dewatering
- Filter-bag or filter-bin for final dewatering

Hydrocyclone: 6” urethane or metal at 15-20 psi pressure drop
Underflow slurry to filter bag/bin
Use filter-bag for open system and filter-bin for closed system
Bag/bin ~1.0 m³ oleophobic and reusable

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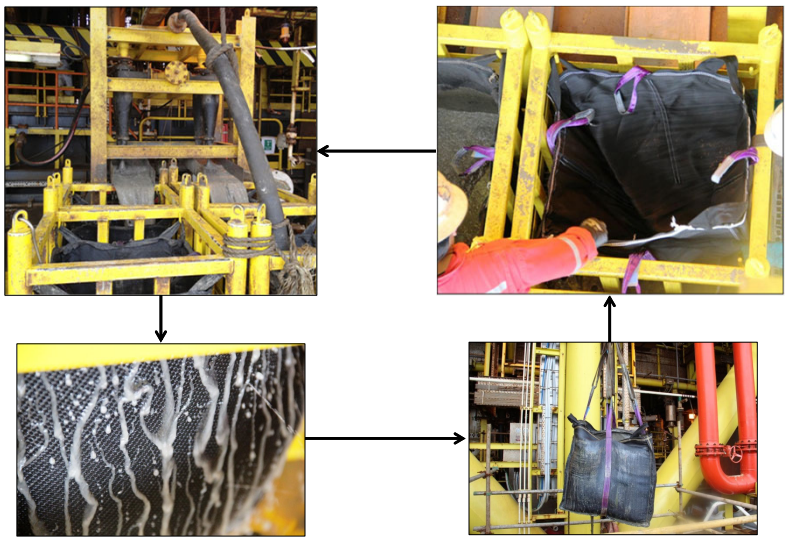
SLURRY DEWATERING



Deepwater production floating facility (OTC Asia paper in progress)

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SLURRY DEWATERING

GoM fixed facility processing slurry from liquid desander (SPE 63041)

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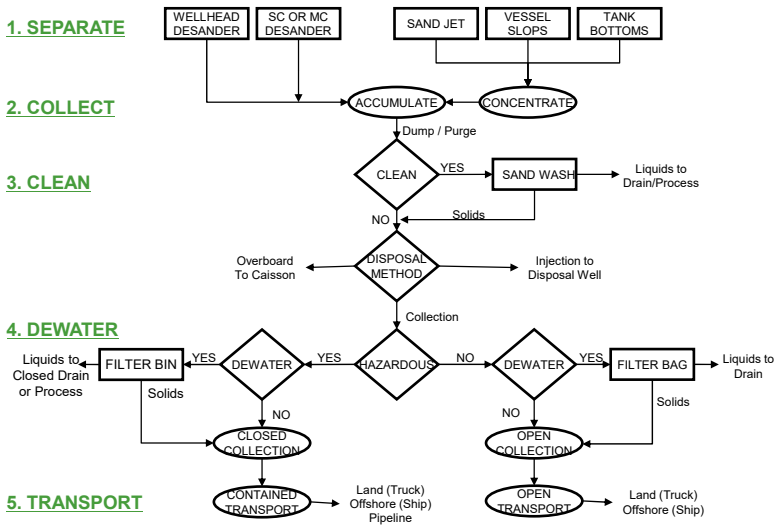
SYSTEM DESIGN



Methodology detailed in SPE 72999

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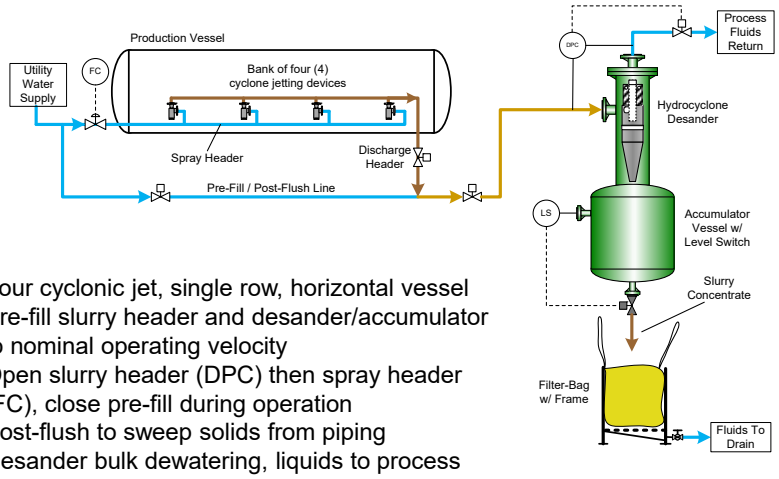
SYSTEM DESIGN



- Four cyclonic jet, single row, horizontal vessel
- Pre-fill slurry header and desander/accumulator to nominal operating velocity
- Open slurry header (DPC) then spray header (FC), close pre-fill during operation
- Post-flush to sweep solids from piping
- Desander bulk dewatering, liquids to process
- Accumulator batch discharge (LS or time)
- Filter-bag for gravity drain and solids transport

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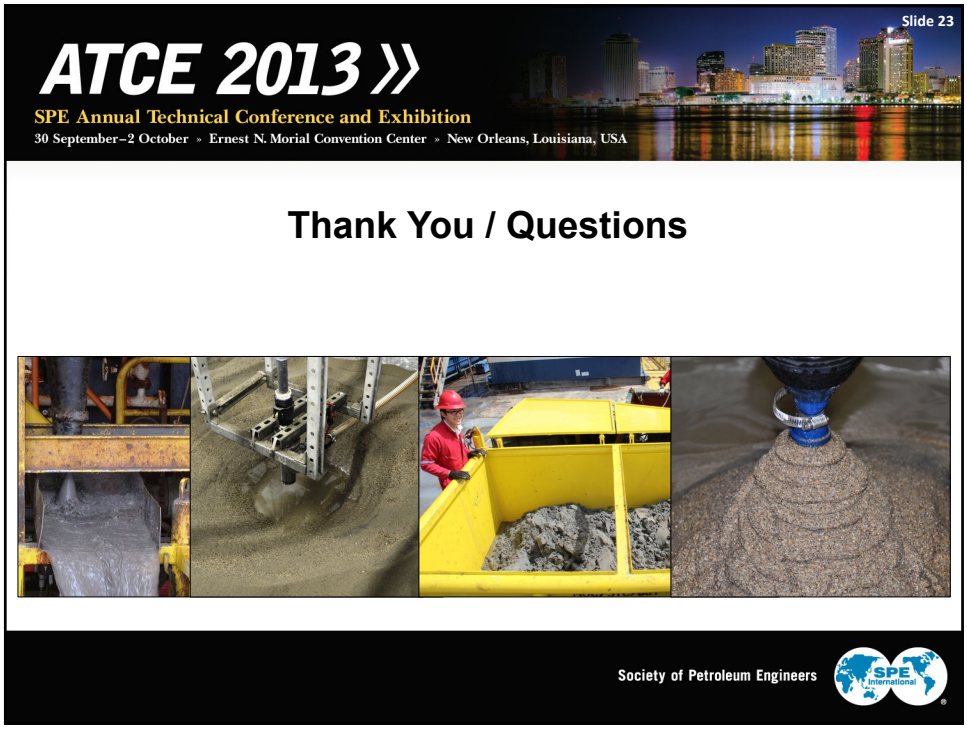
SUMMARY

- Production Separators Require Solids Removal (pre or in-situ)
- Cyclonic Solids Jetting Device
  - Based on hydrocyclone principles
  - Provides shielded vortex sand removal
  - Installation recommendations: horizontal/vertical/atmospheric
  - Influenced diameter: 120 cm (47 inch) per unit
- Slurry Transportation
  - Erosion velocity, horizontal/vertical transport velocity
  - Piping design and operation
  - Never introduce slurry into empty piping/equipment
- Slurry Dewatering
  - Hydrocyclones, filter-bags, and filter-bins
- System Design
  - Five-step methodology for facilities sand management
  - On-line solids removal, transport, dewatering, and transport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Thank You / Questions
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