voith.com

VOITH

Voith Turbo ™
Tech Update: EcoStart™ Engine Start

Thad Berry

EcoStart™
Tech Update Agenda

- Introduction to Voith
  - Very Brief, I swear
- Concept History
- Concept Design
- Industry Issues and Solutions
- Conclusion

Voith in Figures
Overview

VOITH

In more than **60** countries

19,000 Employees

5 Markets

R&D ratio

5.3 %

Family-owned since

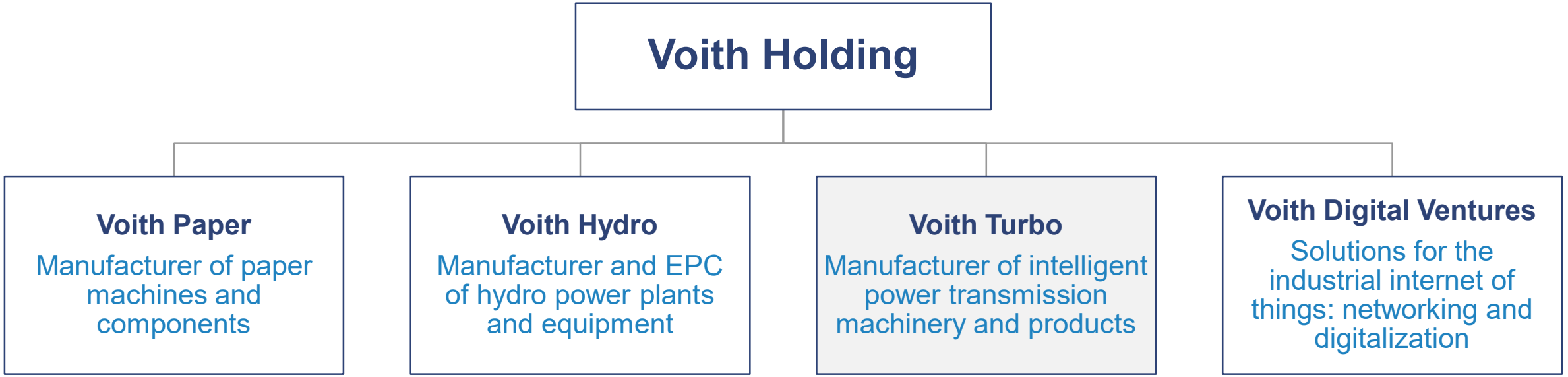
1867

Sales

$4.7 Billion

As of: 2016/17

Four Divisions
A Well-Positioned Company



EcoStart™
Concept History

VOITH

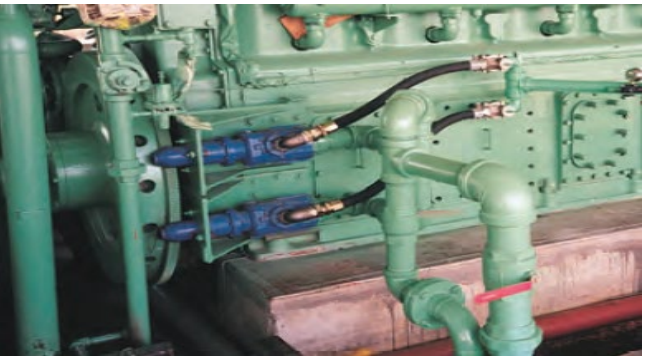
- Mar. 2015 - Voith begins discussion regarding hydraulic start systems based on feedback from industry contacts, concept is submitted to our Innovation Pipeline
- Nov. 2015 - Voith Turbo R&D team explore feasibility and approval is given to proceed with development as all components can be developed internally by Voith
- May 2016 - Approval for prototype testing achieved
- Nov 2016 – Testing of prototype begins, launch customer identified
- June 2017 – Launch customer begins procurement process for 1K HP Skid
- November 2017 – Second customer Issues PO for redundant 4K HP Skid
- December 2018 – FAT for EcoStart Skids Completed
- April 2019 – Ecostart Commissioning Completed
- Jan 2020 – Final Sign Off Completed

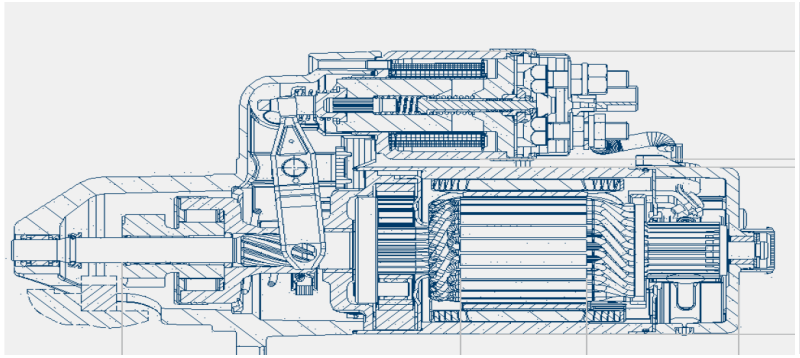
EcoStart™
Concept History: Competitive Landscape

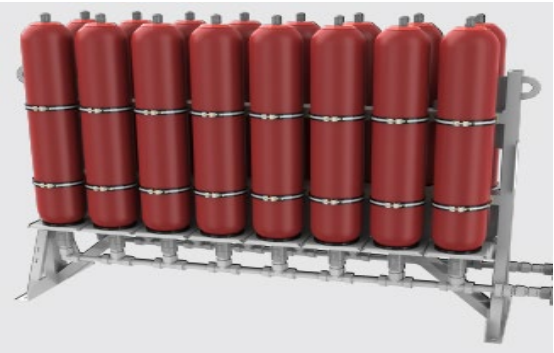
VOITH

Improved performance compared to competitor technology:

- Gas starter systems – Vented Emissions, Safety
- Air starter systems – Vastly smaller footprint, O&M
- Electric starter systems – Impractical for large recips
- Hydraulic starter systems – No comparable designs at present







EcoStart™

Hydraulic Start System for Recip Engines 1000 – 9000 HP

System Design

- Single Skid can tie into multiple engines
- Hydraulic Accumulator and Nitrogen bottle pairs provide stored start energy
- Starter Engagement Motors use existing ring gear and mounting points
- Integrated Control System
- Indoor / Outdoor (ExProof/ NonEx)
- Simplex or Redundant Pump Motor Units

EcoStart™
Issue No. 1: Emissions

- Increasingly stringent regulatory environment impacting all segments of Midstream Industry
  - Gas Start Systems largest source of vented emissions
- Commodity prices incentivize minimal product loss
  - What are lost product costs for each engine start attempt
  - Can ROI be quantified
- Electrical Consumption and Carbon Offsets
  - Will we impact the local grid conditions, especially at remote sites
- Noise pollution
  - Start attempts can produce >120 decibels

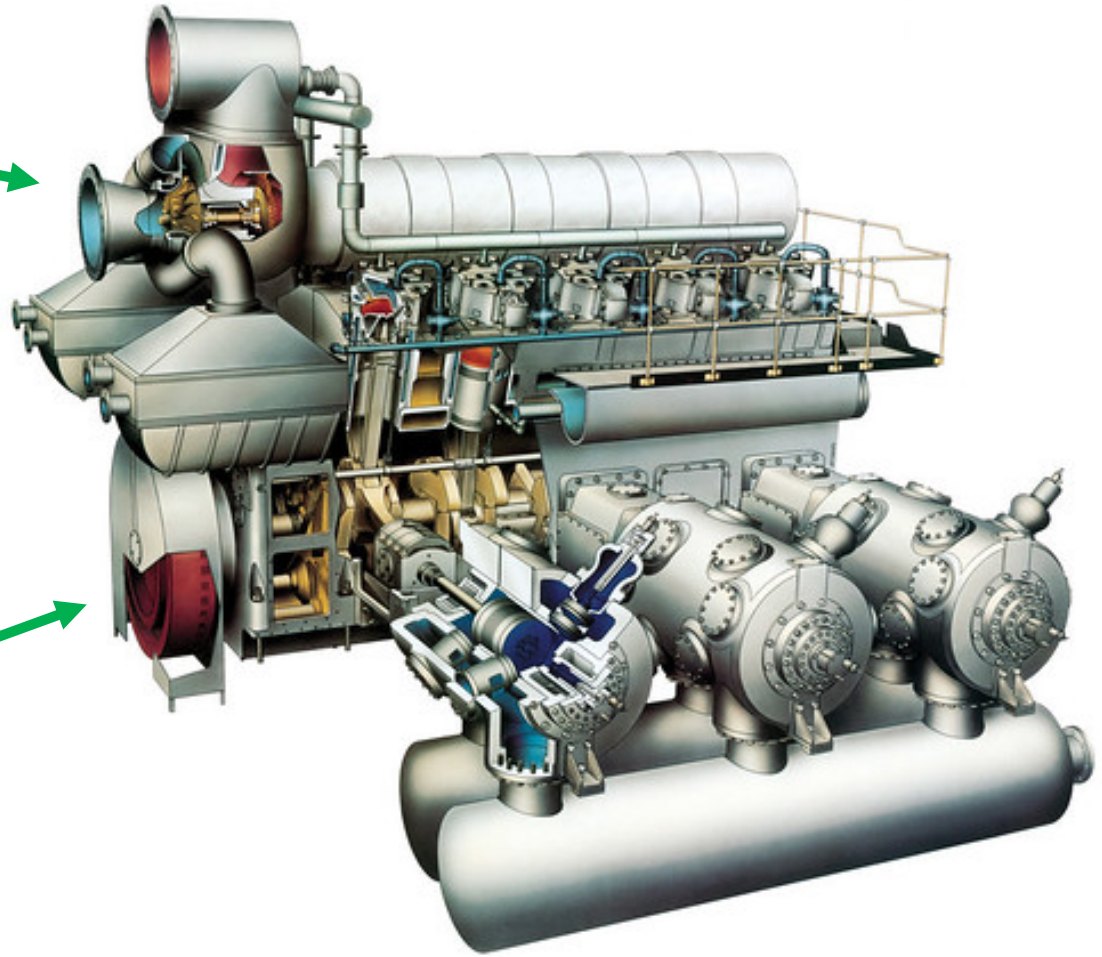
EcoStart™
Solution: Emissions and Costs

- All Hydraulic Start system eliminates vented emissions during start up
- No Product Loss during start attempts
- 10 – 15 HP Motors for EcoStart Pump require 15 – 30 Amps (up to 50 if redundant)
  - Should not overload available power supplies
  - No supporting infrastructure for grid tie in required
  - Auxiliary drives reduces other consumers
  - Pump motor not always active
- Less than 85 decibels at three feet at all phases

EcoStart™
Solution: Emissions

Turbo Assist: Drive turbos for 30 minutes after Start

Pre / Post Lube Drive: Drive Pre and Post Lube Pumps from EcoStart skid



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Issue No. 2: Start Reliability

- Gas Starters allow multiple start attempts
- Air Start technologies have several considerations that can be addressed
  - Limited Start Attempts
  - Recharge Times
- Reduce potential penalties for missed start calls
  - What are grid conditions at remote sites
  - Can we reduce electrical power consumption during start cycles

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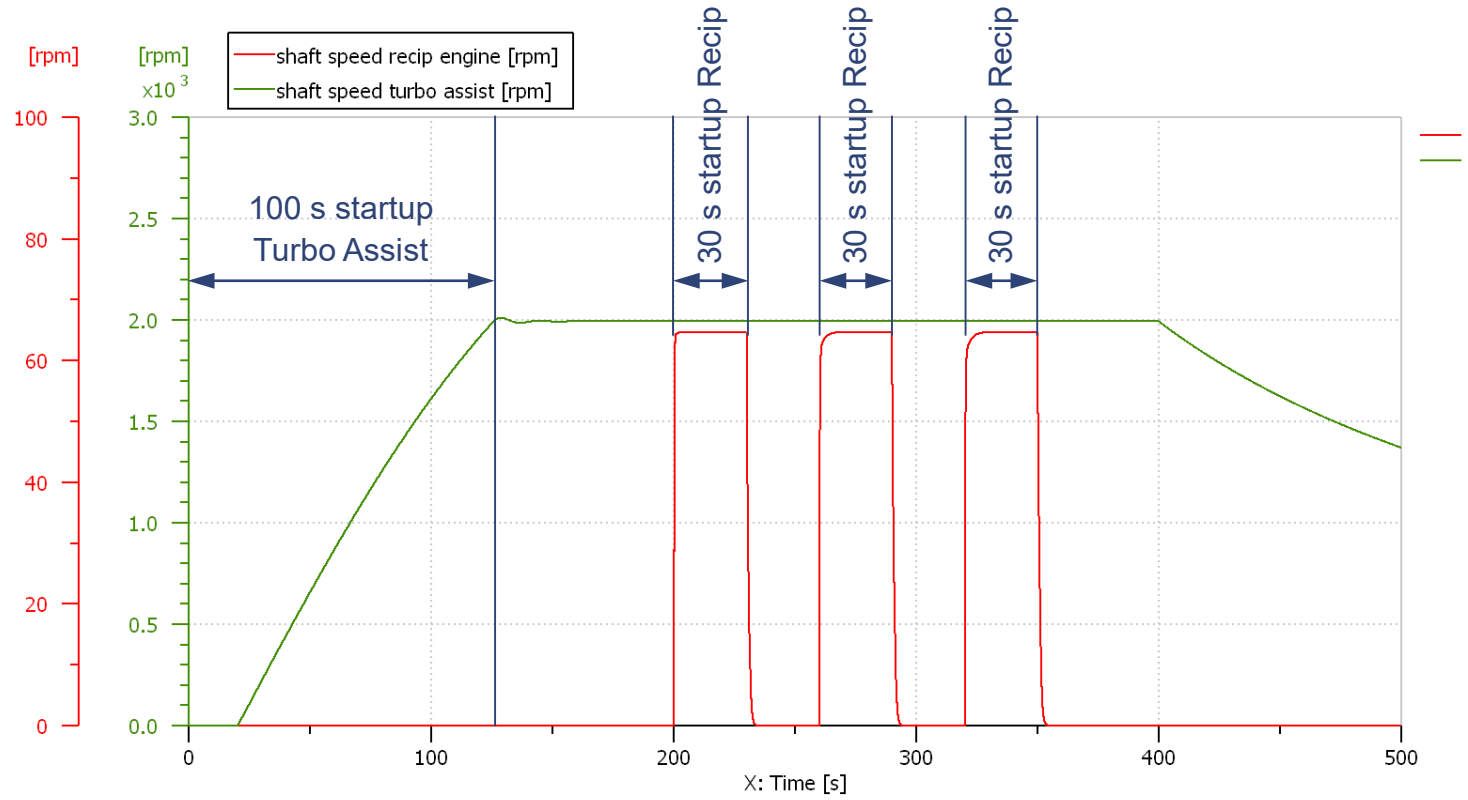
Volumetric Flow



EcoStart™
Solution: Start Reliability

- Original Concept called for 3 x 30 Second Start Attempts per charge
  - Accumulator bank determines starting capability
  - System Recharge time varies, but less than 15 minutes from min to full prime
- Black Start capability as hydraulic charge is stored
- Multiple skids at site can be interconnected (theoretically)
- Starter Engagement Motor Design

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Issue No. 3: Safety

- Greatest number of safety incidents occur during maintenance turns
  - Pneumatic jacking system most common means of turning driveshaft
    - Potential for back drive hazardous to personnel
    - Unintended motor start possible
- Can alternative systems be built to meet site requirements
  - New technology acceptable to site personnel
  - Area Classification

EcoStart™
Solution: Safety

- EcoStart uses precision control of hydraulic output to allow slow roll for maintenance turns
  - 1 ½ RPM for 4000 HP system
  - 6 RPM for 1000 HP system
- Maintenance function can be controlled by Engine Control Panel or remote control pendant
- One direction of rotation only
- No specialized training required

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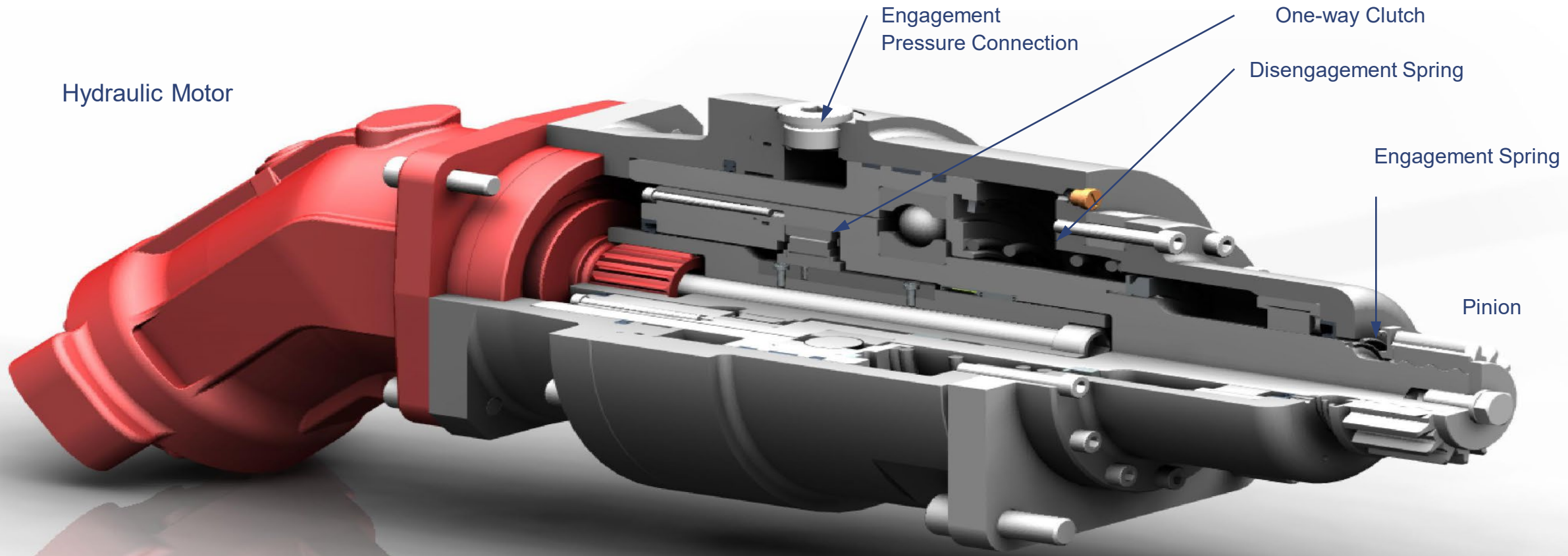
Issue No. 4: O&M and Service Support

- Gas Start Systems very simple and low O&M requirements
- Air Start relatively simple, but design varies
  - Pneumatic piping
  - Head wear with Air to Start systems
- Is local support and parts availability an issue
- Current Starter Engagement Motor options
  - Some legacy models difficult to maintain
  - TBO varies between make and model
  - Ring Gear wear

EcoStart™
Solution: O&M and Service Support

- We use 1” to 1 ½” inch piping hydraulic piping, 2 “ for drain
- Hydraulic accumulators require annual nitrogen charging
- Service Reps based in nationwide locations
- 24/7 parts availability integral part of Service Plan
  - EcoStart assembled in the US
  - Most components are COTS, Controls platform is Allen Bradley
- Starter Motors designed for many starts
  - Over 2000 starts on Test Stand, no internal wear
  - Soft engagement greatly reduces ring gear wear

Starter Engagement Motor
Designed to Fit in Existing Motor Mount



EcoStart™
1000 HP Skid After FAT

Key Facts:

- Size - 95" x 67" x 91"
- Weight - 5,000 lbs
- 5 x Hydraulic Accumulator and Nitrogen bottle pairs

EcoStart™
4000 HP Skid After FAT

Key Facts:

- Size - 120" x 96" x 100"
- Weight - 8,000 lbs
- 25 x Hydraulic Accumulator and Nitrogen bottle pairs (20 for production units)
- Assembled in US
- Service Group based out of US facilities

EcoStart™
Conclusion

Current Status:

- Over 120 engine starts
  - 4 missed starts, not due to Voith
- Ongoing incorporation of field/ design notes
- Standardized Design finalization by Mar 20
- Assembly moved to US
- Service Plan development in final stage

Thank you!

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VOITH

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