RT-flex common-rail system
vs
other types electronic controlled low-speed engine

Electronic low-speed engine development

- **1981: 1st generation RTX-1** (Hydraulic jerk pump), the **SUSIG** concept

- **1990: 2nd generation RTX-2**, (Hydraulic jerk pump & electr. controlled exhaust valve), the **SUSIG** concept
  - Development driven by **Su**lzer, development partner **SIG** in Schaffhausen
  - Extensively tested on test engine in Winterthur but abandoned due to:
    - Lack of flexibility in injection
    - Combined pressure generation and injection rate shape control
    - Time controlled injection, no possibility for volumetric fuel injection
    - No possibility for single injection nozzle operation on low load
    - High fluctuation in high pressure hydraulic oil demand
    - Large hydraulic power pack needed
    - Accumulators needed for pressure pulse damping
    - High manufacturing costs

  The competitor‘s ME engine is based on the SUSIG concept
  Key technology from the original Sulzer development partner SIG,
  today Curtiss Wright

- **1998: 3rd generation RTX-3**, RT-flex common rail
- **2008: 4th generation RTX-4**, RT-flex common rail

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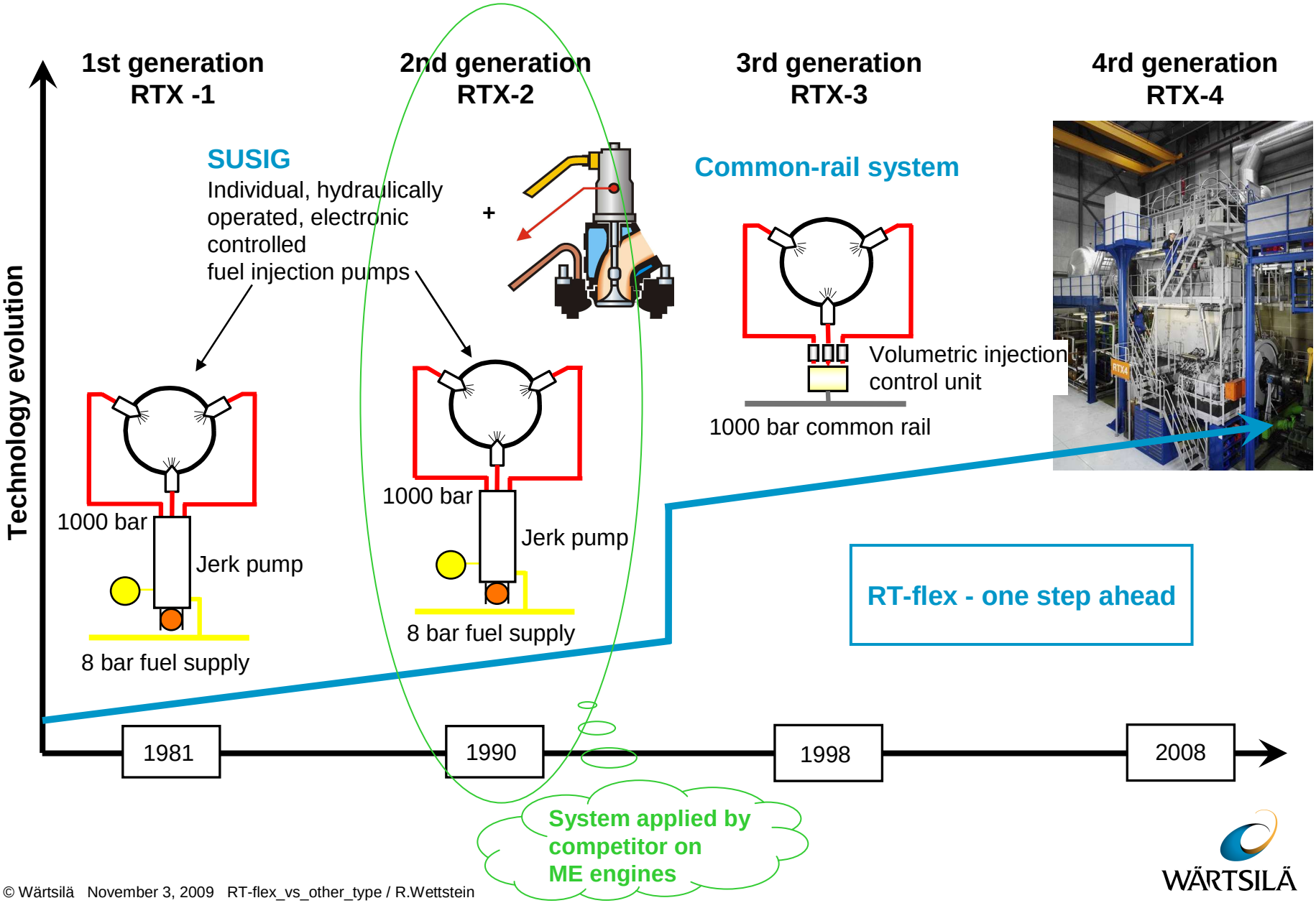
Electronic low-speed engine development



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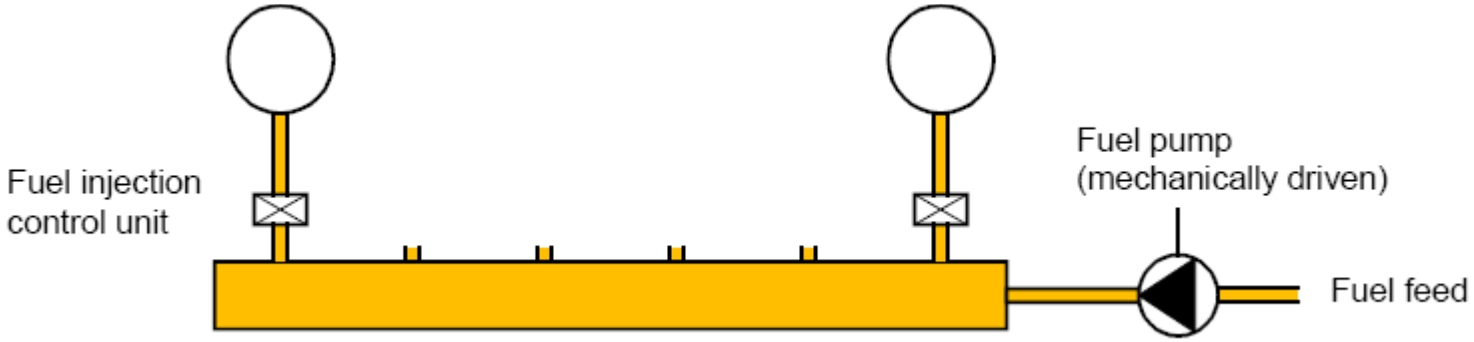
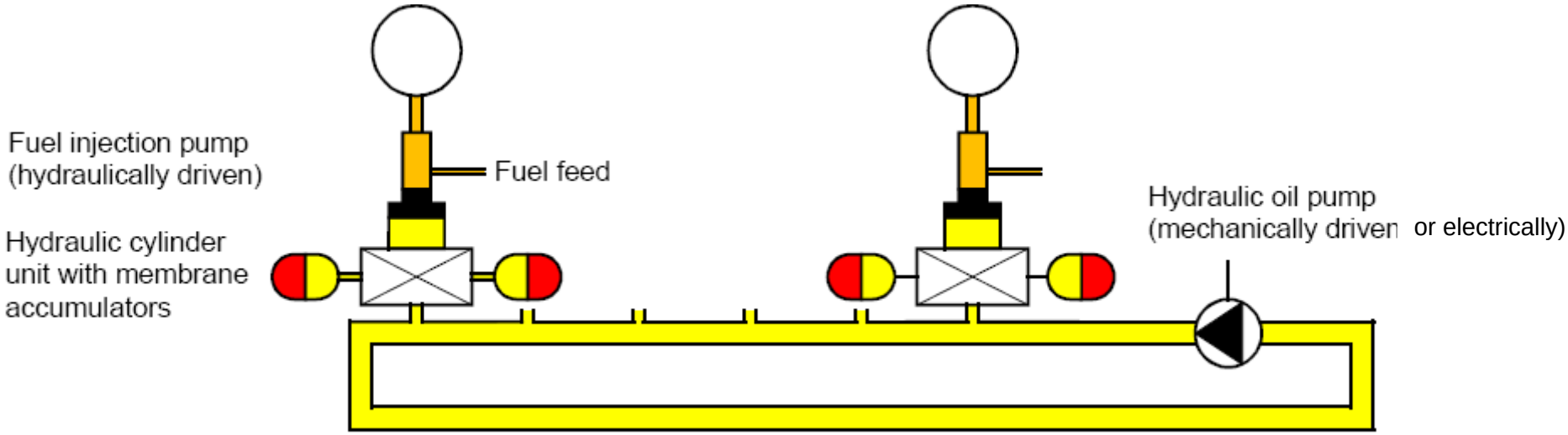
RT-flex vs SUSIG- type fuel injection

RT-flex common-rail system



SUSIG system as applied on ME



Efficiency loss in the hydraulic system

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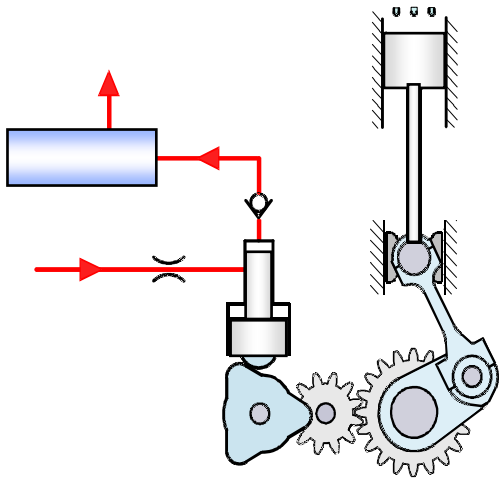
Fuel pressure generation (1)

- Supply unit *(RT-flex)*
  - Direct, mech. driven pumps
  - High efficiency, Bosch- type pump
  - Built-in redundancy

    --> CSR power available even one pump fails



- Single pump principle *(SUSIG)*
  - Indirect, hydraulic-driven jerk pumps

    --> heat losses in hydr. system

    --> lower engine efficiency
  - Loss of one cylinder in case one fuel pump fails

    --> load reduction

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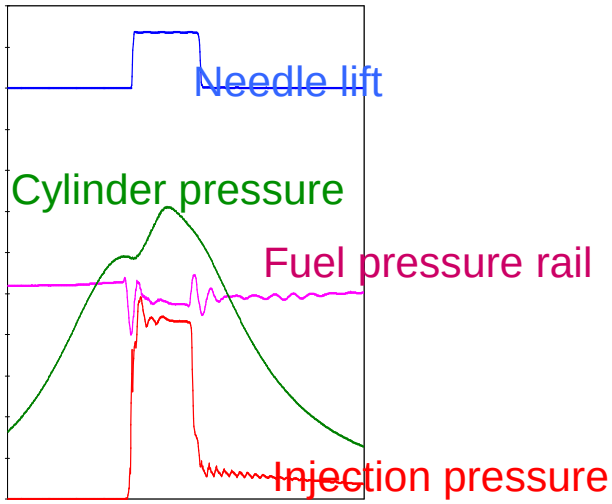
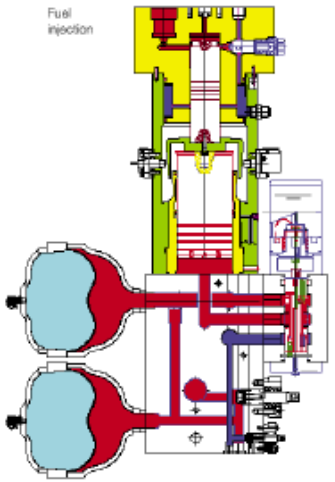
Fuel pressure generation (2)

- Common rail *(RT-flex)*
  - Common rail volume provides sufficient pressure dampening
    --> no need for accumulators

- Single pump principle *(SUSIG)*
  - Fast hydraulic actuation
    --> high pressure peaks
    --> membrane accumulators
    100 bar nitrogen
    --> maintenance / replacement





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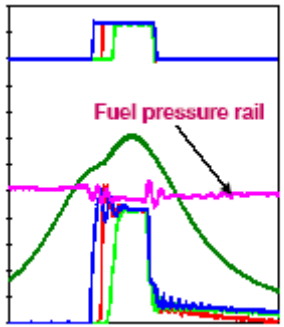
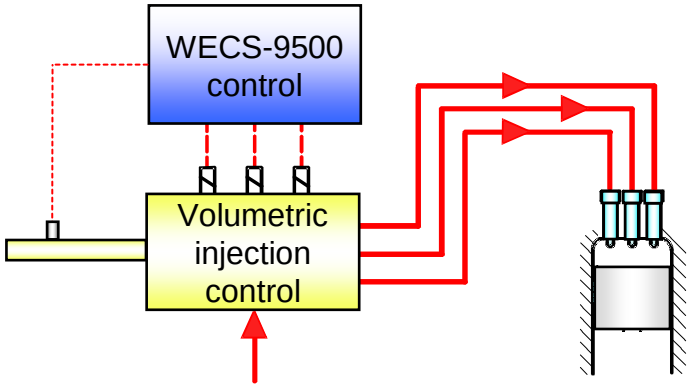
Fuel nozzle control

- Individual nozzle control *(RT-flex)*
  - Sequential injection
    --> low NOx mode

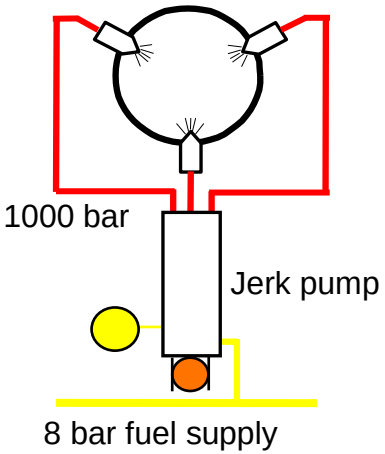


  - Single nozzle injection
    --> smokeless operation at slow steaming



smokeless operation down to 10 to 12% rpm R1

- Common nozzle control *(SUSIG)*
  - No sequential injection
  - No single nozzle injection



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Summary

	RT-flex	SUSIG-type
Pump principle	One supply unit - Direct mech. driven pumps - High efficiency, Bosch type pump - Built-in redundancy → CSR power available even one pumps fails	One complete electro-hydraulic driven pump system per cylinder - Indirect, hydraulic-driven jerk pumps → heat losses in hydraulic system → lower engine efficiency - Loss of one cylinder in case of one fuel pumps fails → load reduction
Pressure control	Independent control	Combined pressure generation and injection rate shape control
Nozzle operation	Individual nozzle control - Sequential injection: low NOx mode - Single nozzle injection: Smokeless operation at low steaming	Common nozzle control - No sequential injection - No single nozzle injection
Smoke	Smokeless operation at all loads	Less effective smokeless especially at low load
Maintenance	Less and easier maintenance	Accumulators need regular maintenance and replacement of membrane
Common rail	YES	NO

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Benefits of RT-flex engine (1)

1) Smokeless operation at all operating speeds

- Cleaner combustion space and turbocharger
- Less deposits in exhaust economiser, less risk for boiler fire
- Environmental friendlyness

2) Low steady running speeds (10 to 12 %rpm MCR)

- Improved manoeuvring characteristics, less tug assistance
- Trouble free channel passage (Suez)
- Ideal slow-steaming speed for lightering purpose

3) Reduced part load fuel consumption

- Delta tuning allows reduced fuel consumption at loads below 90%
- Low-Load tuning allows reduced fuel consumption at loads below 75%

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Benefits of RT-flex engine (2)

4) Simpler engine setting

- Fuel quality- and VIT setting via WECS computer

5) Thermally well balanced cylinders

- Improved load balance between cylinders thanks to volumetric injection

6) Extended integrated monitoring

- i.e. injection cycle, exhaust valve movement

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Benefits of RT-flex engine (3)

7) Built-in redundancy (pumps, piping and electronics)

- Built-in capacity to keep engine in operation in case of single point failure

- ***improved efficiency***
- ***higher availability***
- ***higher operational flexibility***

- ***resulting in lower operating costs***

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