Layout of Test Chambers II

4th Training in Rio de Janeiro, BRA

6th-9th of May 2019

Michael Trzesniowski

Co-funded by the Erasmus+ Programme of the European Union

5. Rig Mechanics

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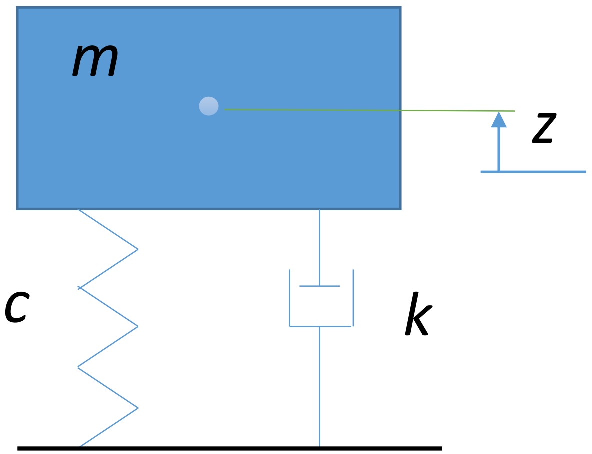
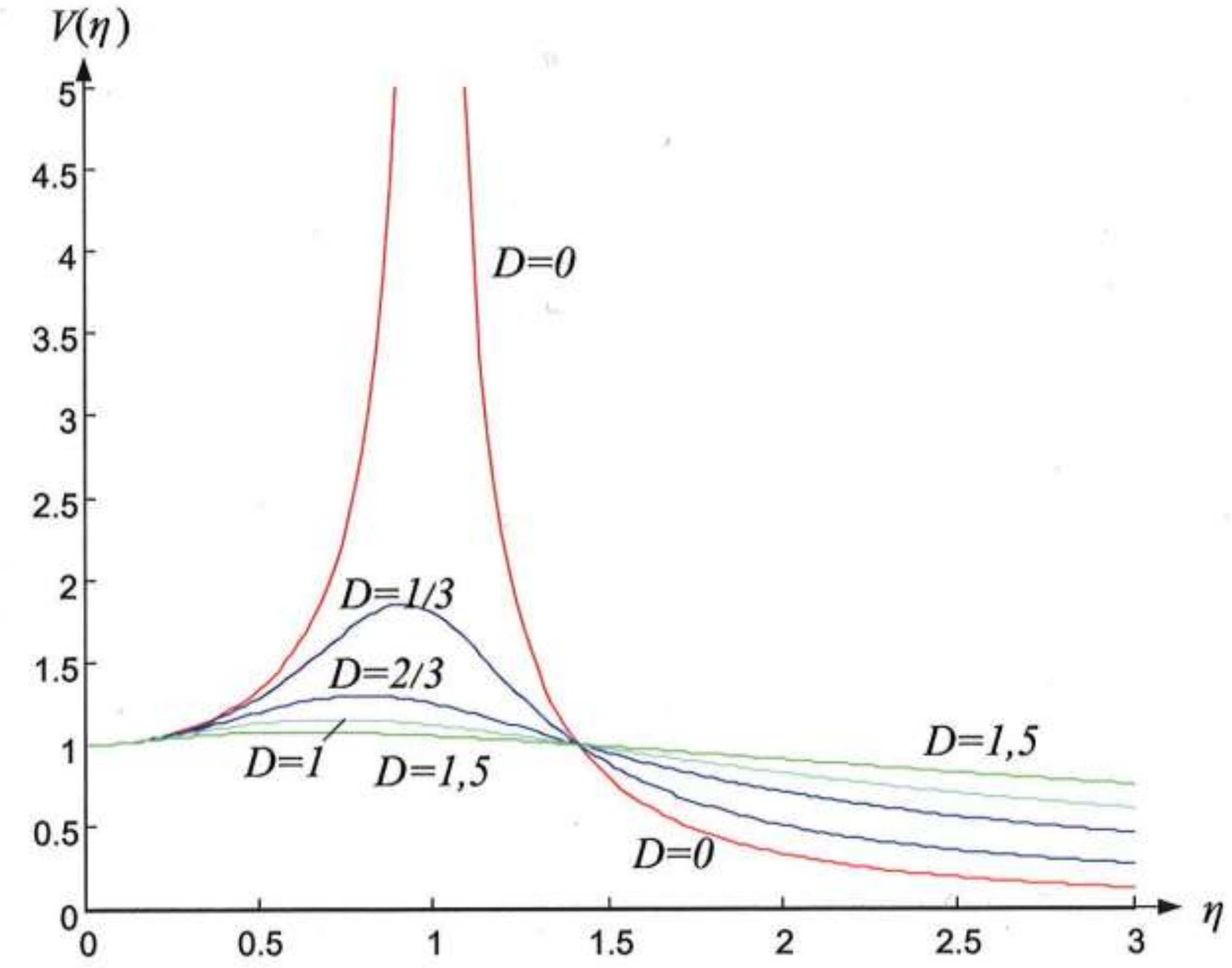
Oscillations



$$\omega_0 = \sqrt{\frac{c}{m}}$$

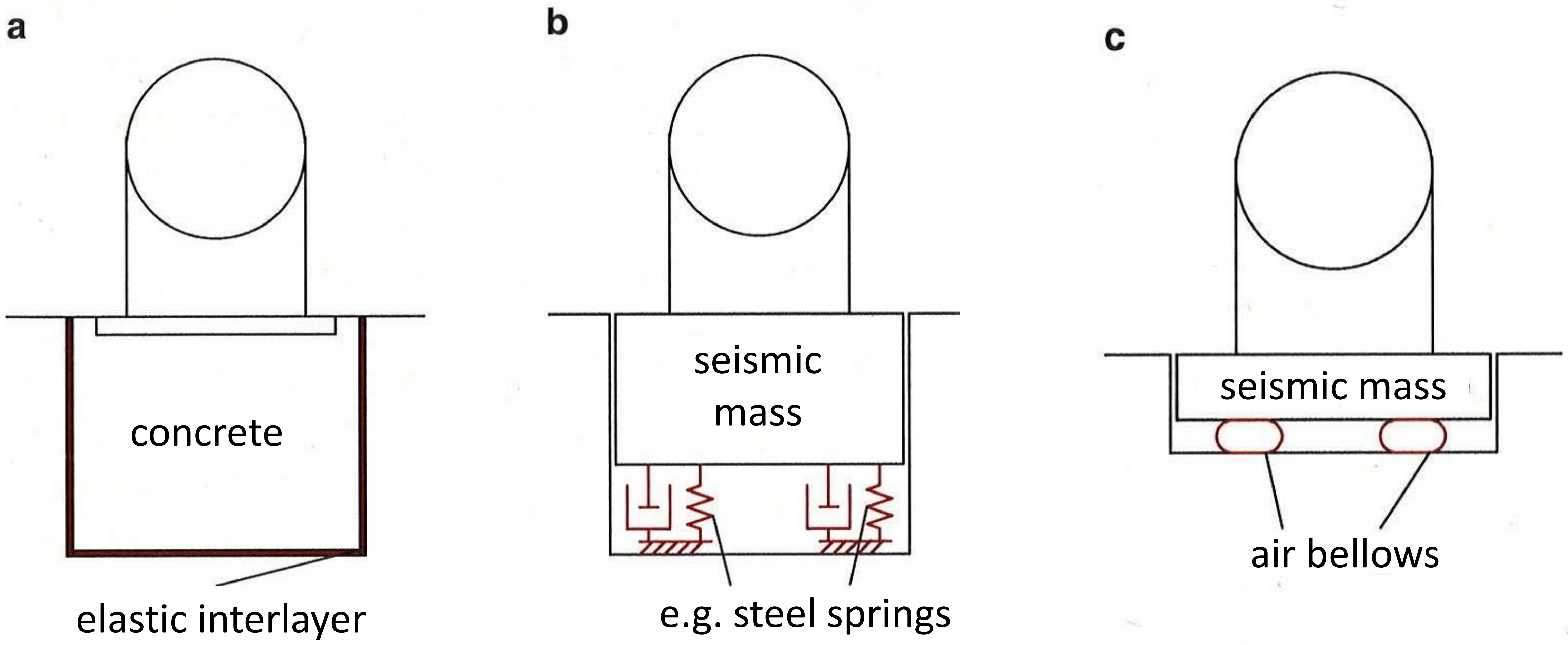
$$\eta = \frac{\omega}{\omega_0}$$

$$D = \frac{k}{k_{crit}} = \frac{k}{2\sqrt{cm}}$$



Transmissibility V

Oscillations



Bedding of baseplate

Co-funded by the
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Baseplate

Seismic mass
(hydraulic ram)

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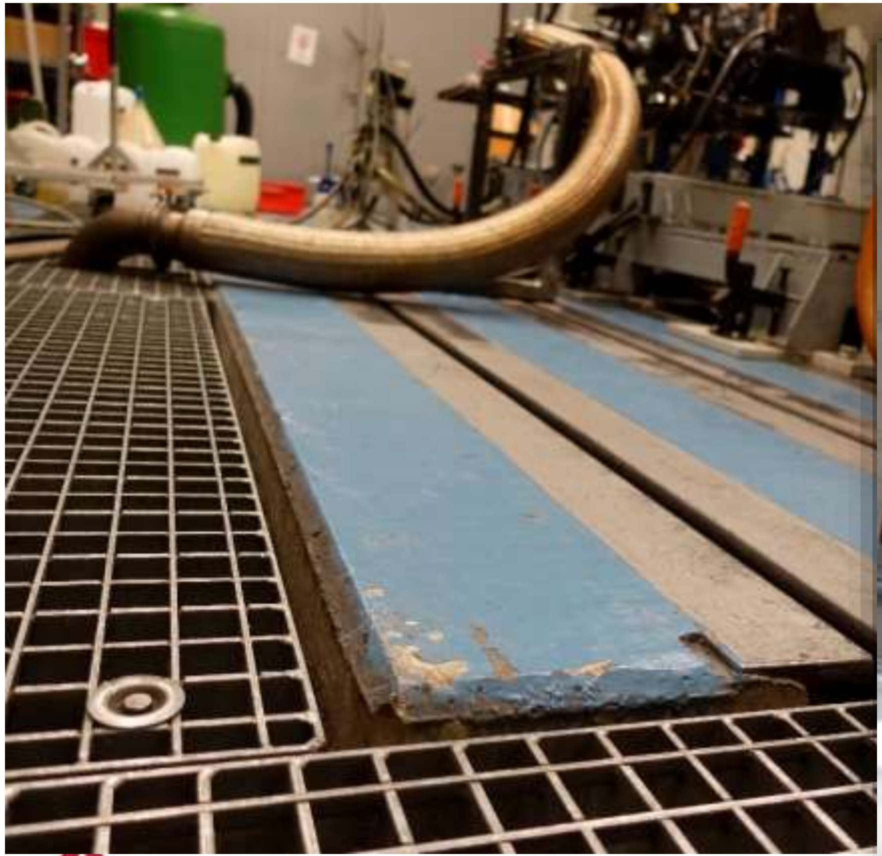
of the European Union

Baseplate

Engine test cell



Baseplate

Transmission test rig

Co-funded by the
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Mechanical connection

Shaft
Joint
Guard

Co-funded by the
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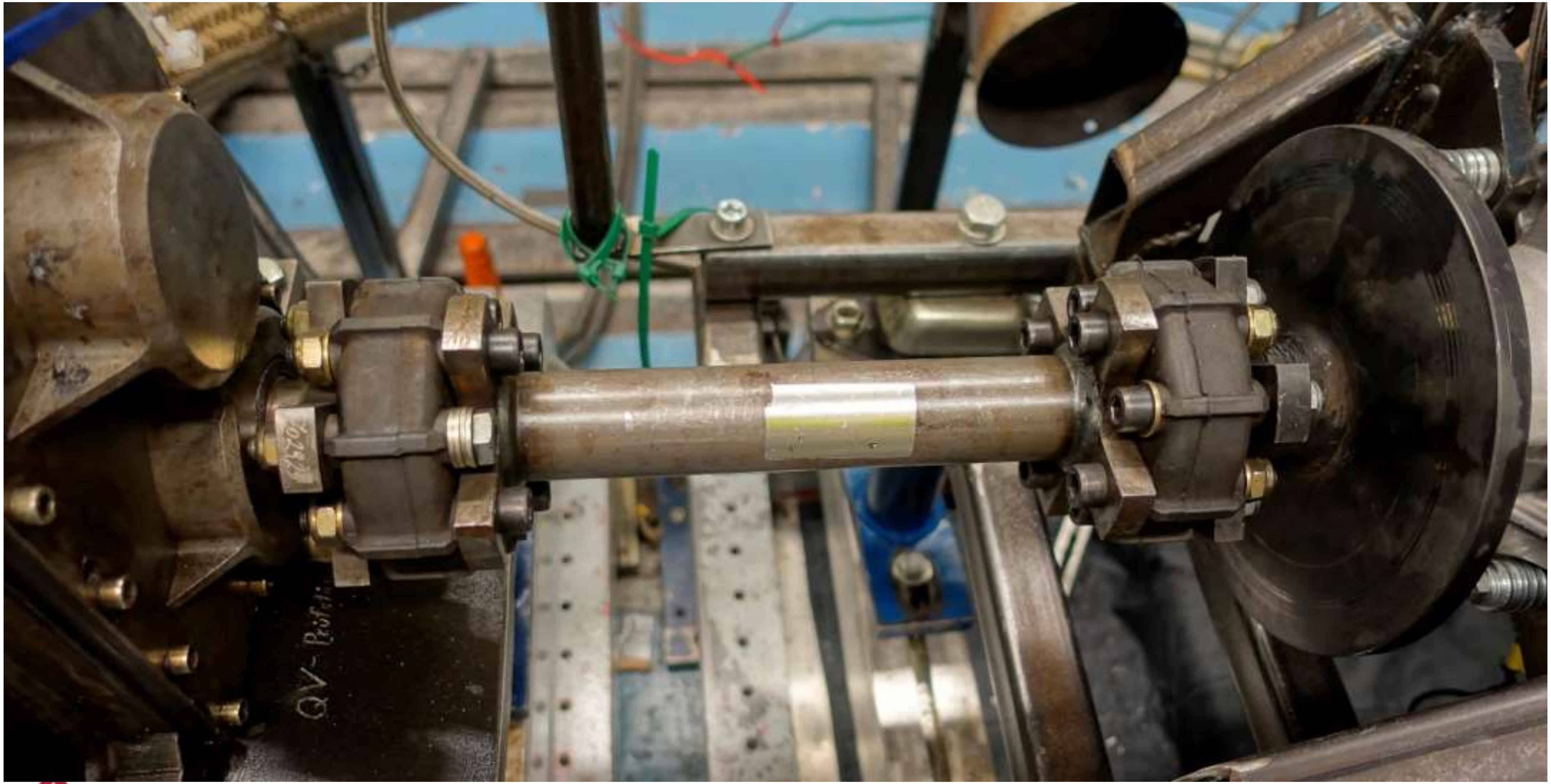
Mechanical connection



Shaft
Elastomeric coupling

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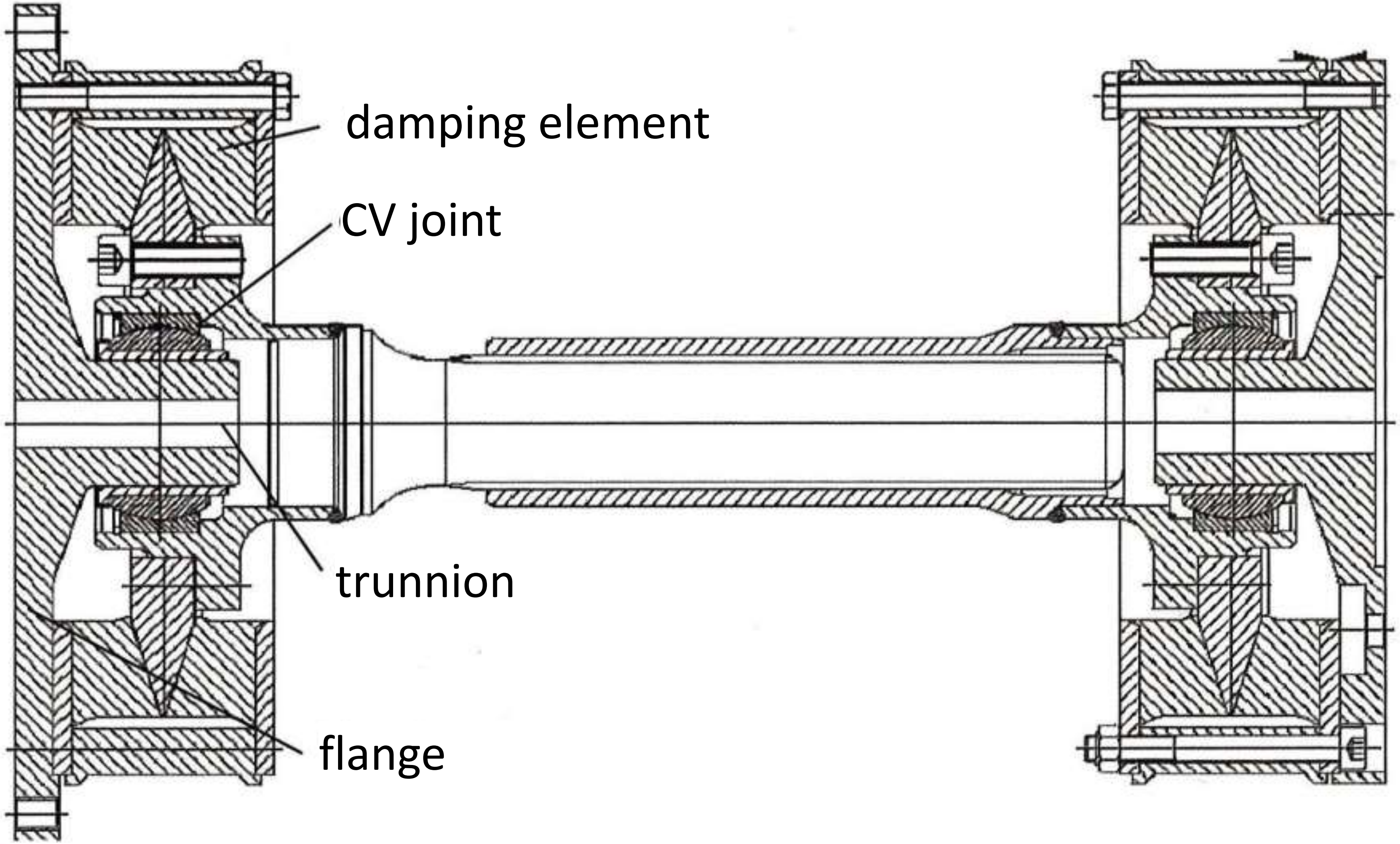
Mechanical connection



Shaft with coupling

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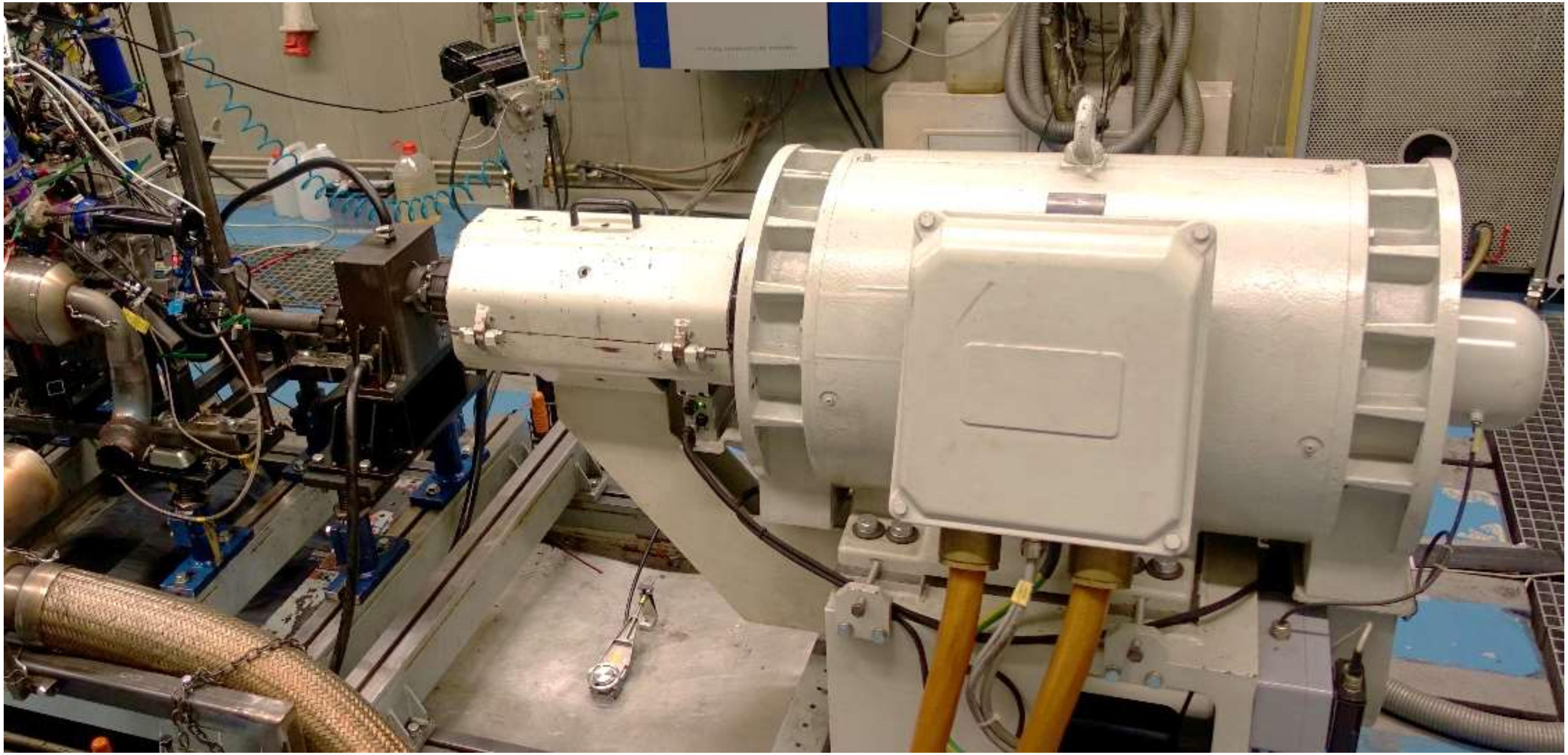
Shaft Guard



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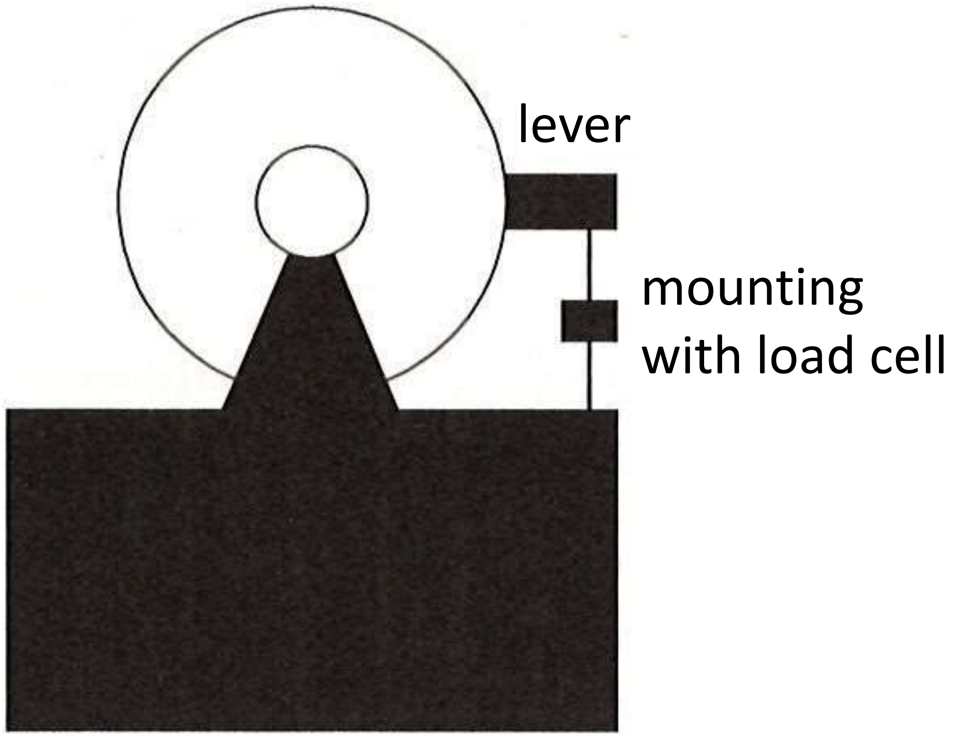
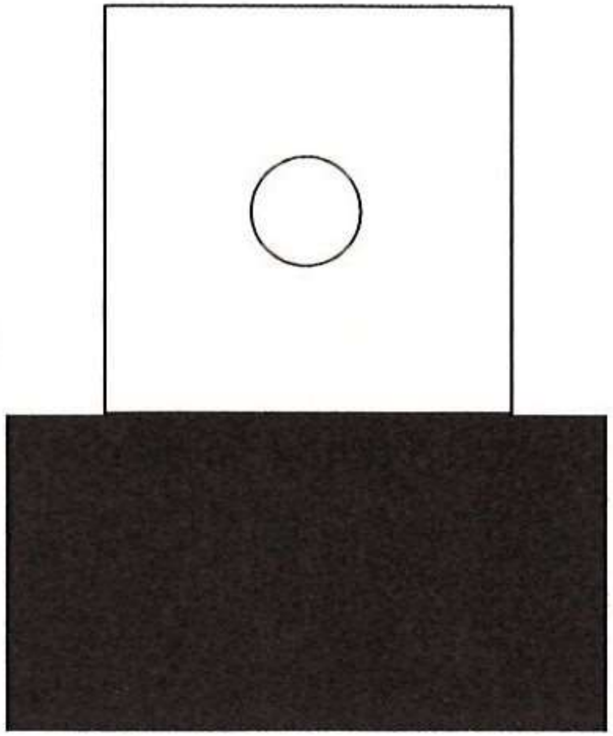
Power Absorber



Trunnion Mounted Electrical Dynamometer



Direct Mounted

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Power Absorber

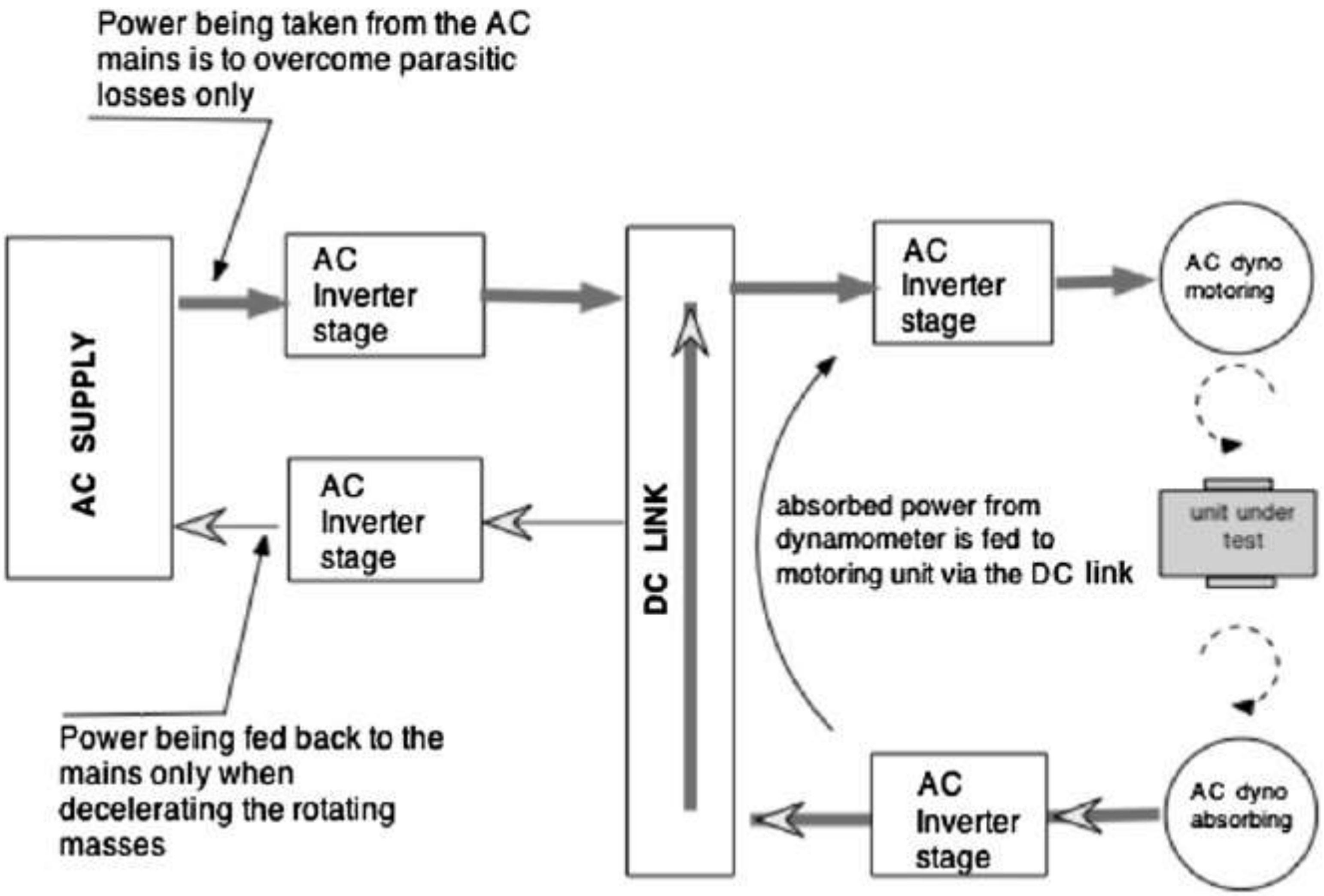

Diagram showing recirculation of electrical power in a transmission test rig comprising two matched AC dynamometer systems

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Power Absorber

Name	WWW	Serie	Power/kW	Max. speed/ rpm
AVL	www.avl.com	Omega	550–12.000	1500–7000
		DynoSpecial	14500–140.000	150–800
Froude Hofmann	www.froudehofmann.com	(R)F	750–29.840	1200–16.000
Fuchino	www.fuchino.co.jp	CF	300–52.000	240–8000
		CFT	1600–74.000	4000–25.000
		CFW	75000–150.000	200–240
		SF	75–1100	2000–8000
Horiba	www.horiba.com	DT	700–4500	2700–7500
Kahn	www.kahn.com	101	51–736	9000–35.000
		102	883–2207	4500–11.000
		108	4707–58.840	4500–15.000
		301	336–993	3600–7500
		404, 405, 406	515–58.840	4500–60.000
Powertest	http://www.pwrtst.com	H 36	1194–7457	2500
		X	373–5966	2500–2600
Piper	www.piper-ltd.co.uk	PB	522–1007	2700–3500
		PH	1641–6711	3600–6000
SAJ	www.sajdyno.com	AWM	14,7–1470	2750–8000
		SH	300–6700	2500–10.500
Superflow	www.superflow.com		1119	15.000
Taylor	www.taylordyno.com	DH	201–600	4500–5500
		DL	410–7457	1800–2550
		DS	1584–3169	4000
		DX	186–1119	4000/6000
		M2	37	6000

Providers of water hydraulic brakes

Co-funded by the Erasmus+ Programme of the European Union

Power Absorber

Name	WWW	Serie	Power/kW	Max. speed/ rpm
A&D	www.aanddtech.com	baugleich API FR		
API	www.api-com.it	FR	5–3200	2500–15.000
AVL	www.avl.com	DynoPerform	20–500	8000–17.000
D2T (von FEV übernommen)	www.d2t.com	DE	80–900	4000–12.000
Fuchino	www.fuchino.co.jp	ESF (H/HA/HS)	0,75-–750	2000–28.000
Horiba	www.horiba.com	WT	190–470	4000–10.000
Meiden	www.meidensha.co.jp	EWD	220–1000	9000–13.000
		TWD	55–750	4000–11.000
Piper	www.piper-ltd.co.uk	PEC	19–400	8000–14.000
SAJ	www.sajdyno.com	SE	10–720	3750–14.000
		WG 225 (nasser Spalt)	168	8000
Sierra CP Engineering	www.sierrainstruments.com	baugleich API FR		
Taylor	www.taylordyno.com	DE	20–720	3500–14.000
Weka	www.weka-motorenpruefstaende.de	MT (luftgekühlt)	7,5–275	3500–6000

Providers of eddy current brakes

Co-funded by the Erasmus+ Programme of the European Union

Power Absorber

Name	WWW	Serie	Power/kW	Max. speed/ rpm
A&D	www.aanddtech.com	ADT	150–600	6000–15.000
AVL	www.avl.com	DynoExact	100–1000	3500–22.000
		DynoRoad	120–1000	3500–20.000
		DynoSpirit	170–700	6000–10.000
Dasym	http://www.dasym.de	H	64–470	9000–15.000
		L	235–1180	3500–5005
		M	265–580	8074–9000
D2T (von FEV übernommen)	www.d2t.com	MDA	160–630	4500–10.000
		MDC	280–800	3500–4000
		DS	34–100	12.000–16.000
FEV	www.fev.com	Dynacraft	66–700	4500–1000
Froude Hofmann	www.froudehofmann.com	AC	140–690	3500–10.000
Horiba	www.horiba.com (höhere Leistungen mit den neuen HP-Maschinen)	$Dynas_3$ HD	460–800	4500–5010
		$Dynas_3$ HT	250–460	8000–1000
		$Dynas_3$ LI	145–460	10.000
		Dynas PM	346	8010
Meiden	www.meidensha.co.jp	FREC	55–550	5000–1000
Taylor	www.taylordyno.com	DA	12–735	3000–11.000

Providers of electrical dynamo-meters

Co-funded by the Erasmus+ Programme of the European Union

Overview Power Absorber

Dyno Type	Advantages	Disadvantages
Variable-fill water brakes Current examples: Froude “F” types, AVL “Omega” range, Horiba DT range	Units can match the most powerful prime movers built. Capable of medium-speed load change, automated control, robust, and tolerant of overload	“Open” water system required. Can suffer from cavitation or corrosion damage
DC electrical motor Produced by most major test equipment manufacturers	Mature technology. Four-quadrant performance. Limited in automotive top-speed range	High inertia, commutator and brushes require maintenance, harmonic distortion of supply possible
Asynchronous motor (AC) Produced by most major test equipment manufacturers	Now mature technology, lower inertia for same rating than DC. Four-quadrant performance. Higher speed range than DC	Expensive. Large drive cabinet needs suitable housing. Care must be taken in environment of the drive unit and the connection into the power system. Some RF emission

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Overview Power Absorber

Dyno Type	Advantages	Disadvantages
Eddy current, water cooled	Low inertia (disk-type air gap) well adapted to computer control. Mechanically simple	Vulnerable to poor cooling supply. Not suitable for sustained rapid changes in power (thermal cycling)
Friction brake	Special purpose applications for very high torques at low speed	Limited speed range

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6. Measuring Instrumentation

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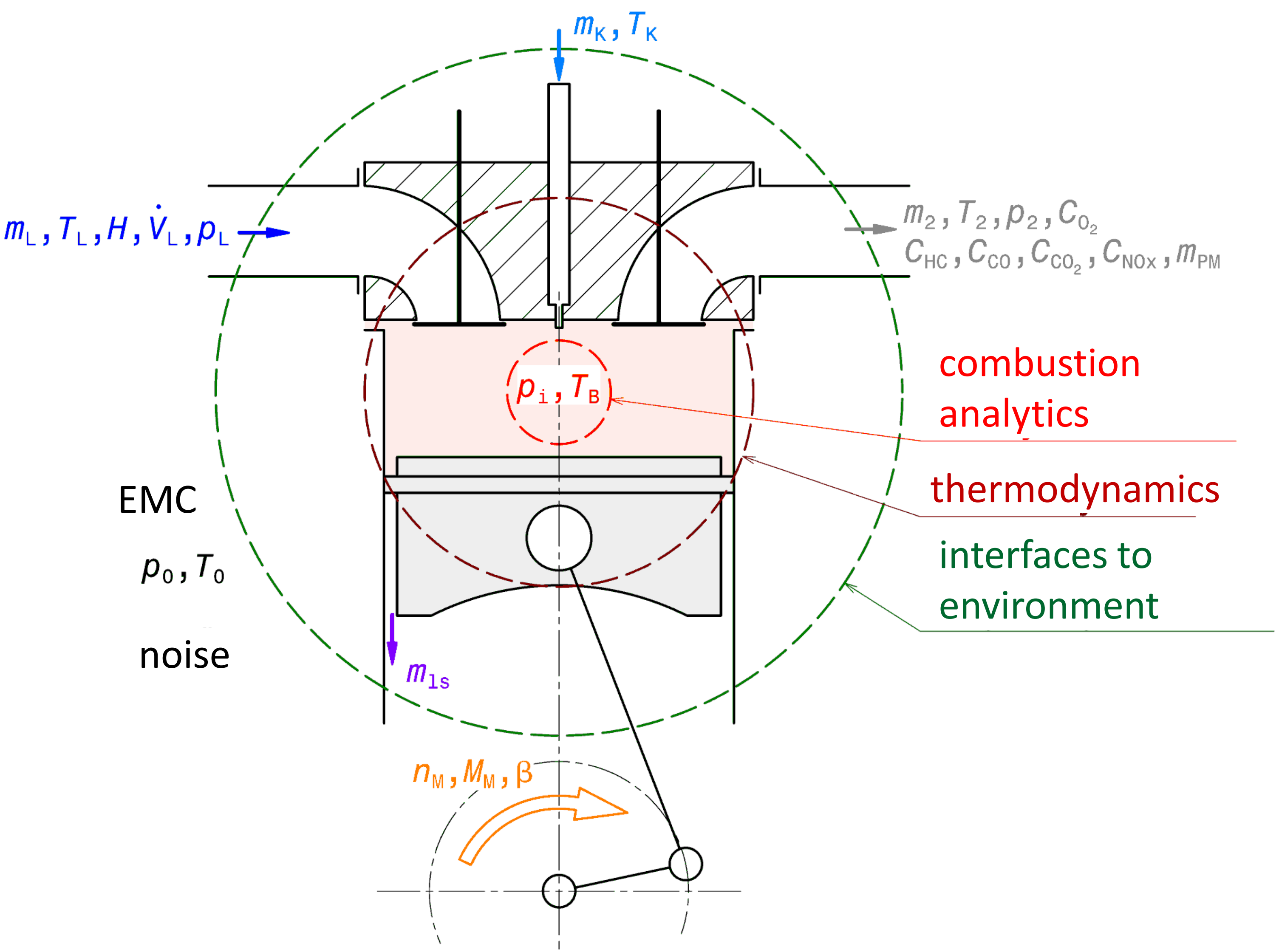
Measurement



Areas of investigation

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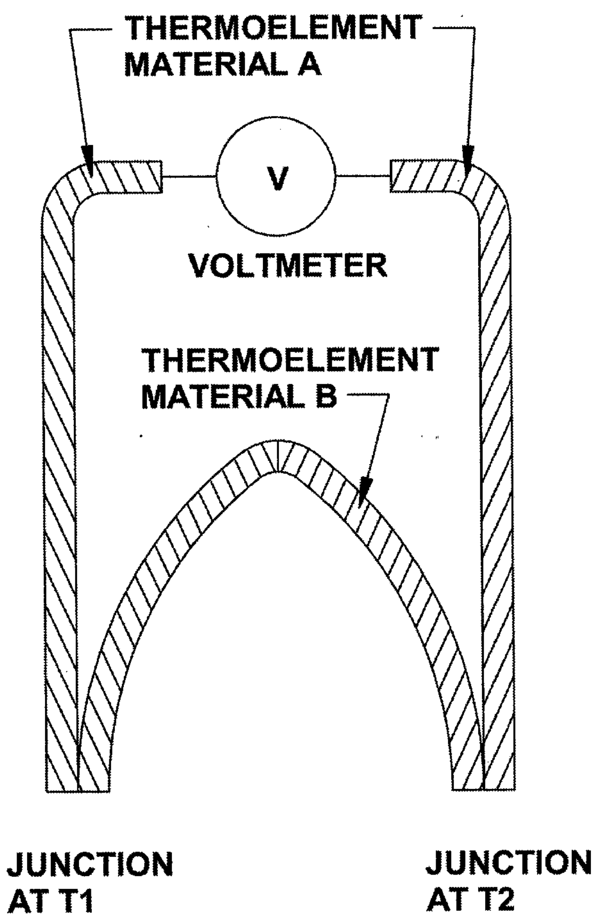
Measurement



temperatures T1, T2

Thermocouple circuit

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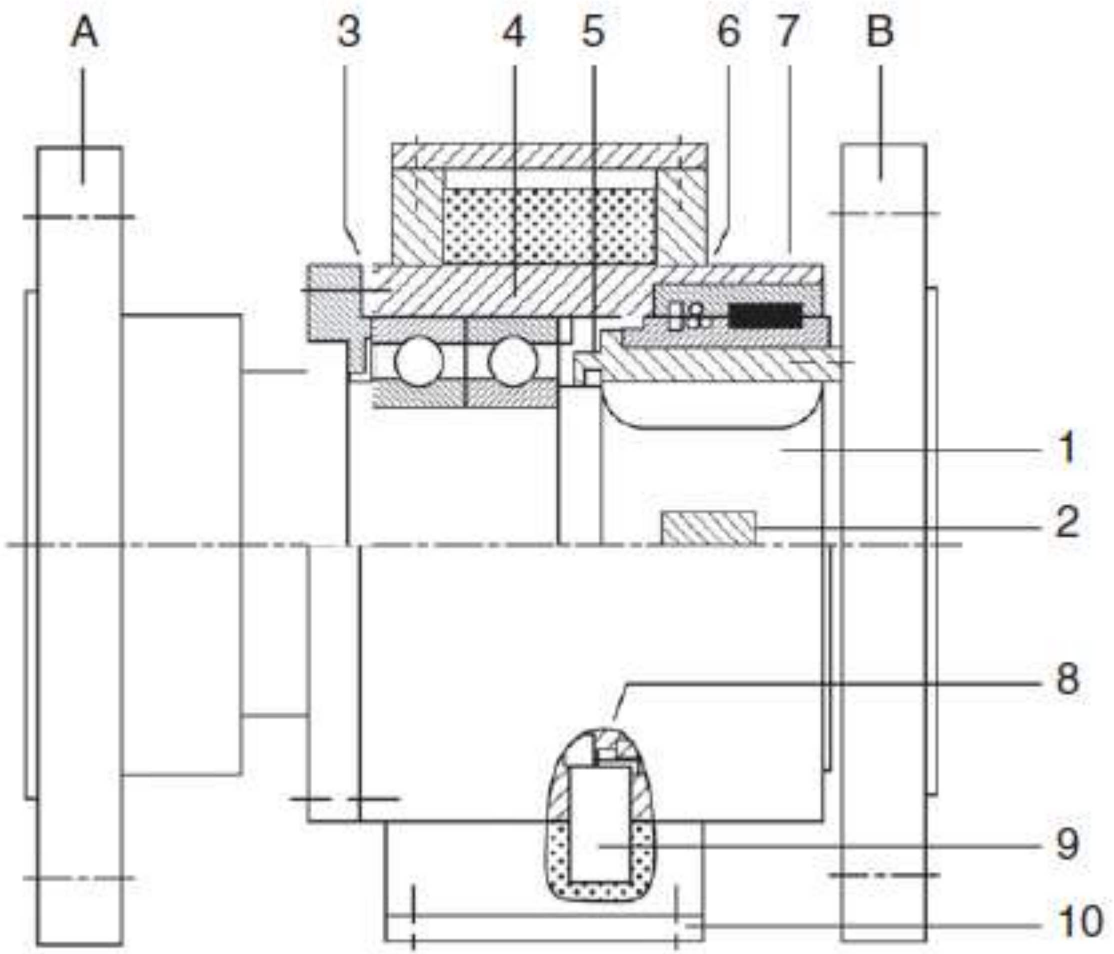
Measurement



A = Mounting flange
B = Flange for torque introduction
1 = Torsion element (rotor)
2 = Applied SGs (strain gauges)
3 = Spindle bearing
4 = Housing (stator)
5 = Elastic seal
6 = Capacitive transmission
7 = Inductive transmission
8 = Toothed ring for speed measurement
9 = Speed pick-up
10 = Cable connection box

Brushless torque shaft for mounting in shaft line between engine and “brake”

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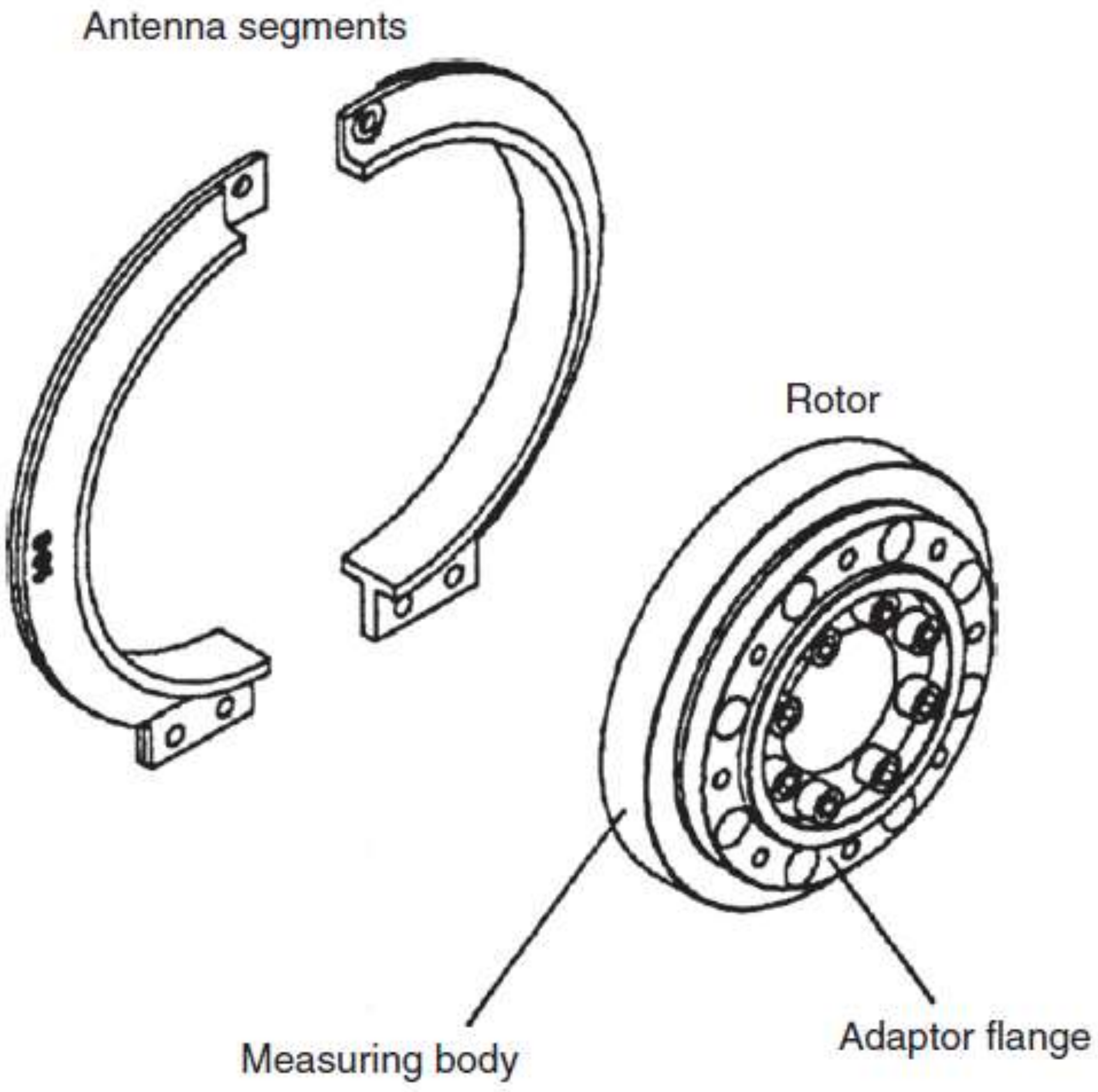
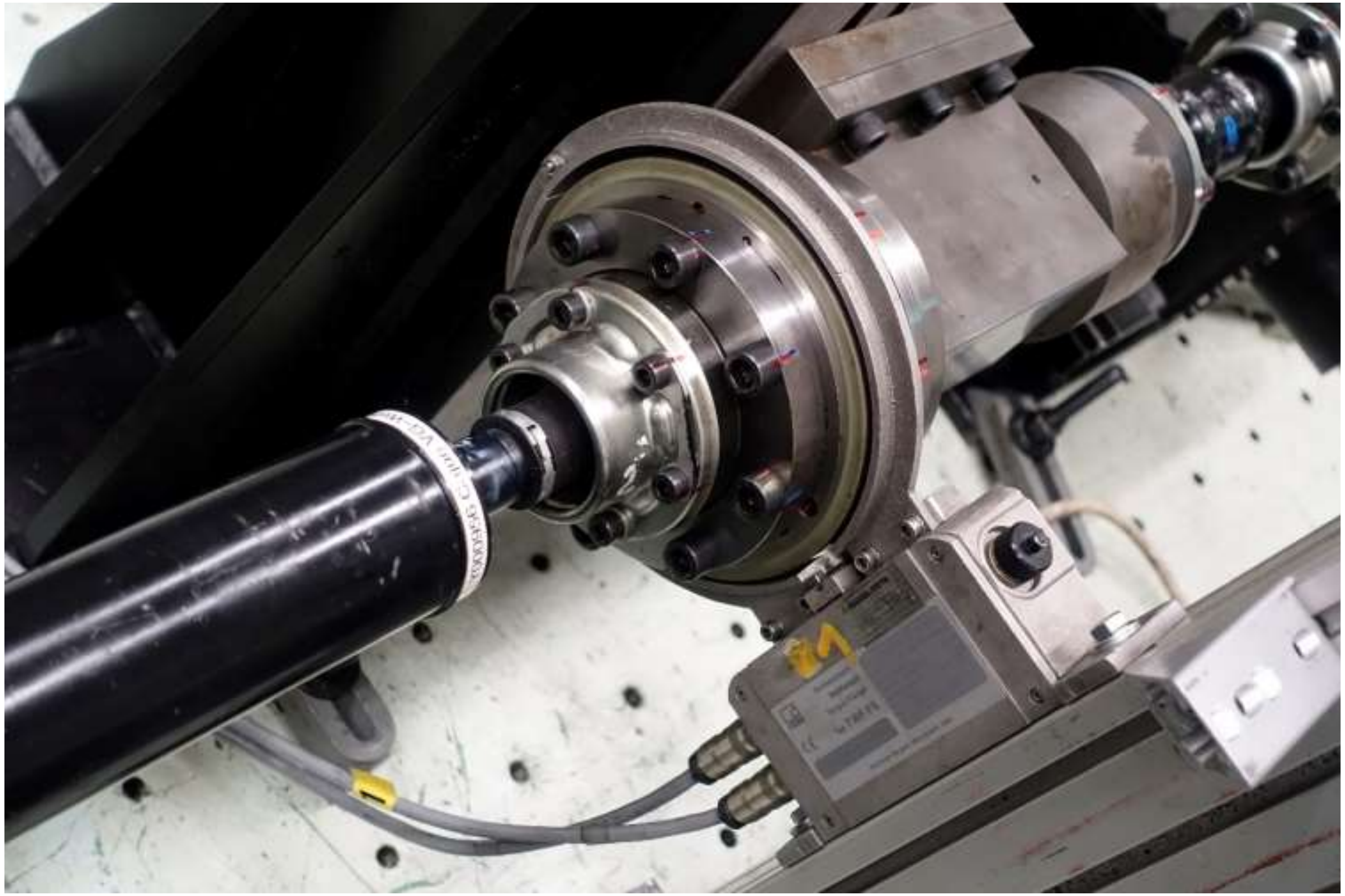
Measurement



Shaft-line components of a torque flange with RF signal transmission

Measurement



Torque flange with RF signal transmission

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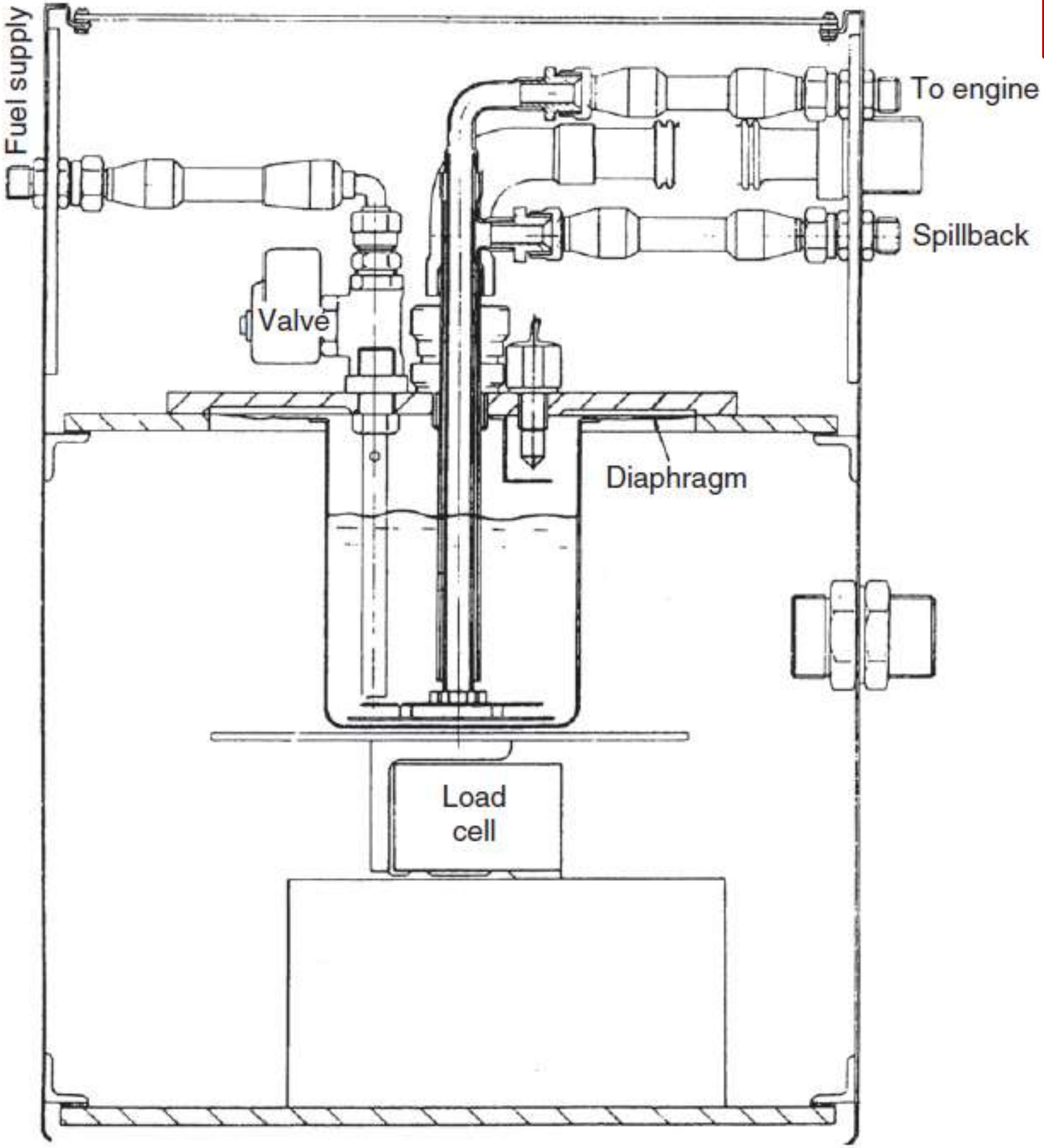
Measurement



Shows a gravimetric gauge designed to meter a mass (rather than a volume) of fuel, consisting essentially of a vessel mounted on a weighing cell from which fuel is drawn by the engine.
A precise time signal at the start and end of the emptying of the cell is given. This signal actuates a counter, giving a precise value for the number of engine revolutions made during the consumption of the measured mass of fuel.

Gravimetric, direct weighing, fuel gauge

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7. Control Engineering

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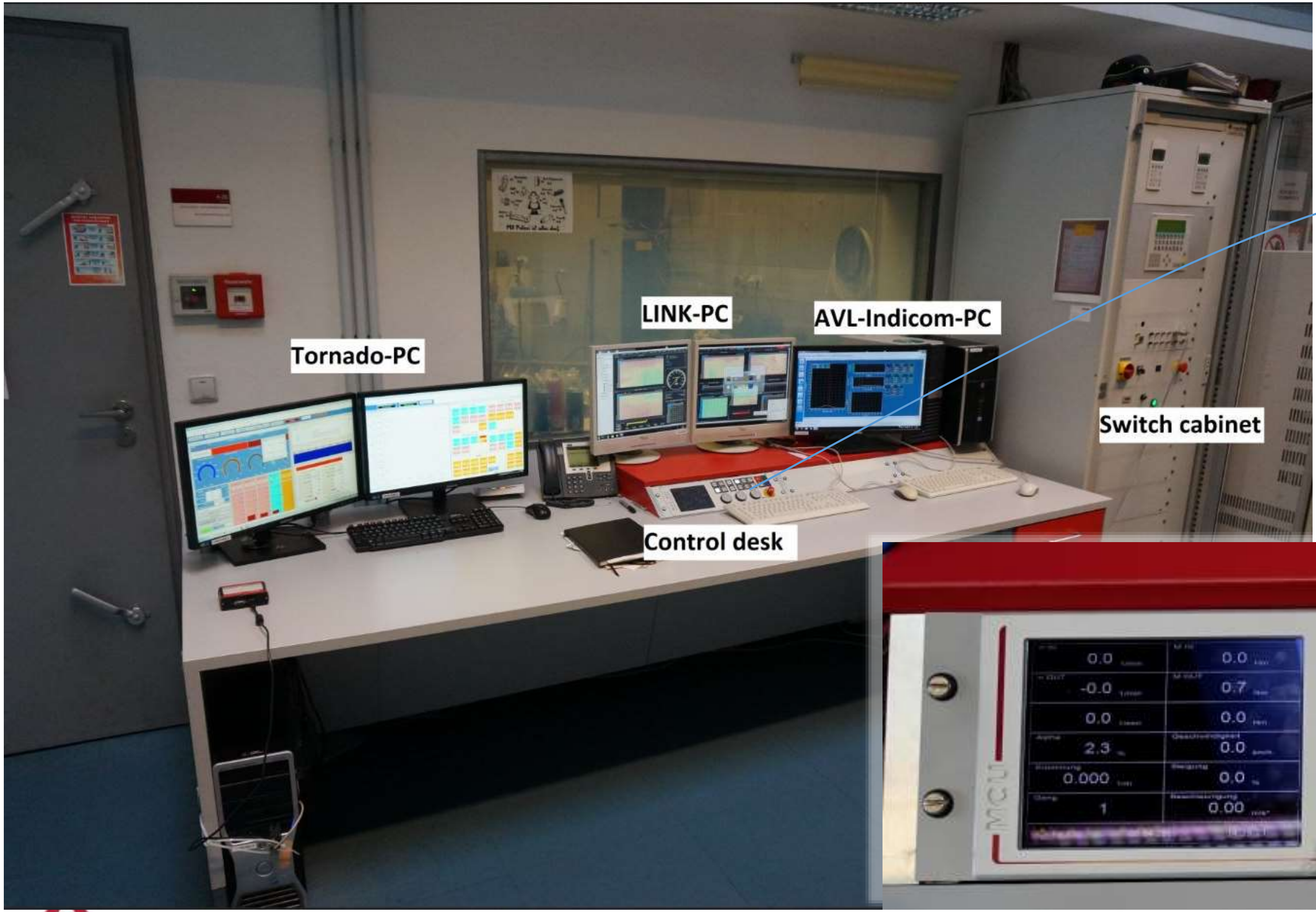
Control Systems



Operators desk

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Control Systems

Main window

Message window

Conditioning window

Screenshot of the left monitor to operate the engine dyno (System Tornado, KS)

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Control Systems

Operating time counter

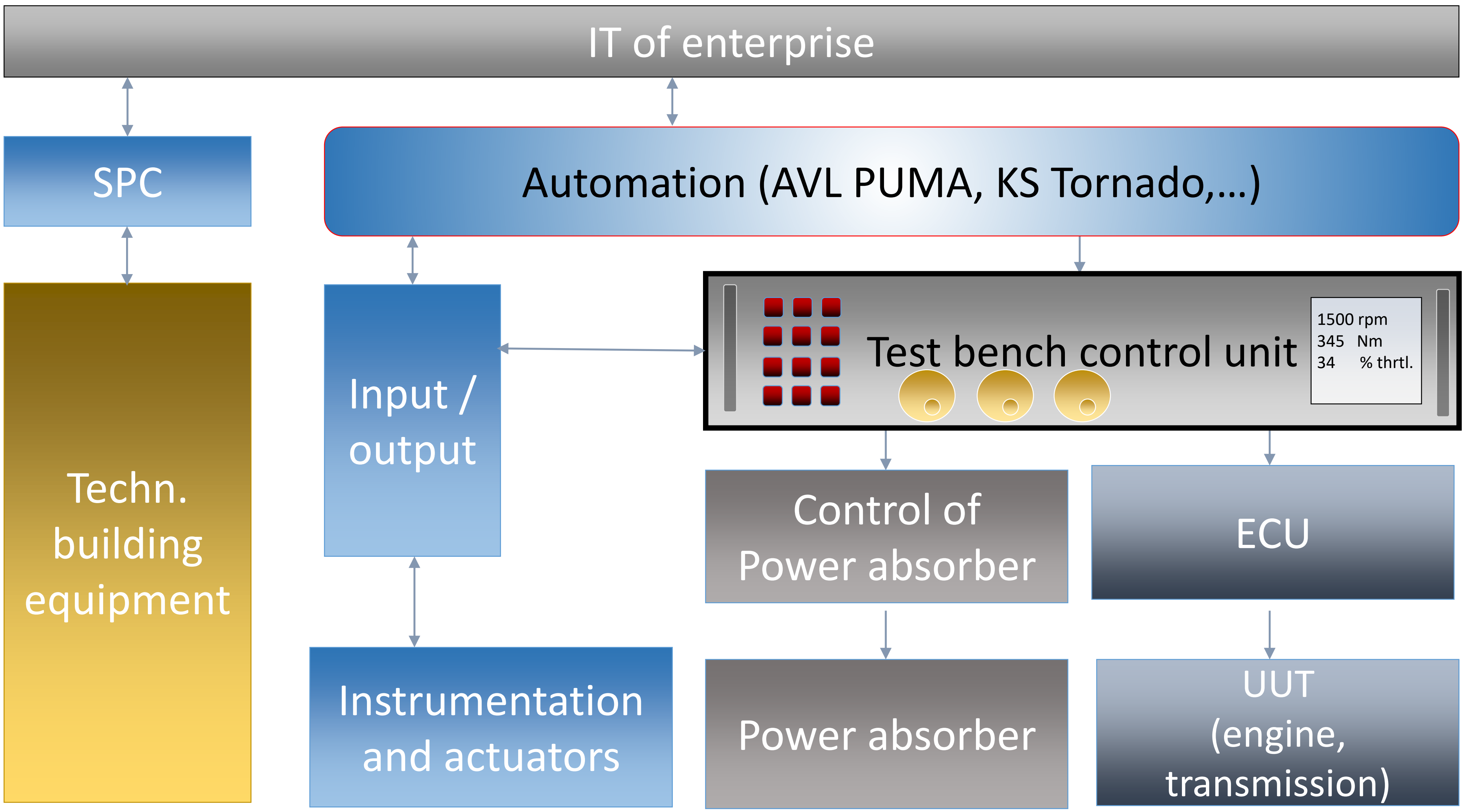
Recorder window

Measurement window

Screenshot of the right monitor to showing measured values (System Tornado, KS)

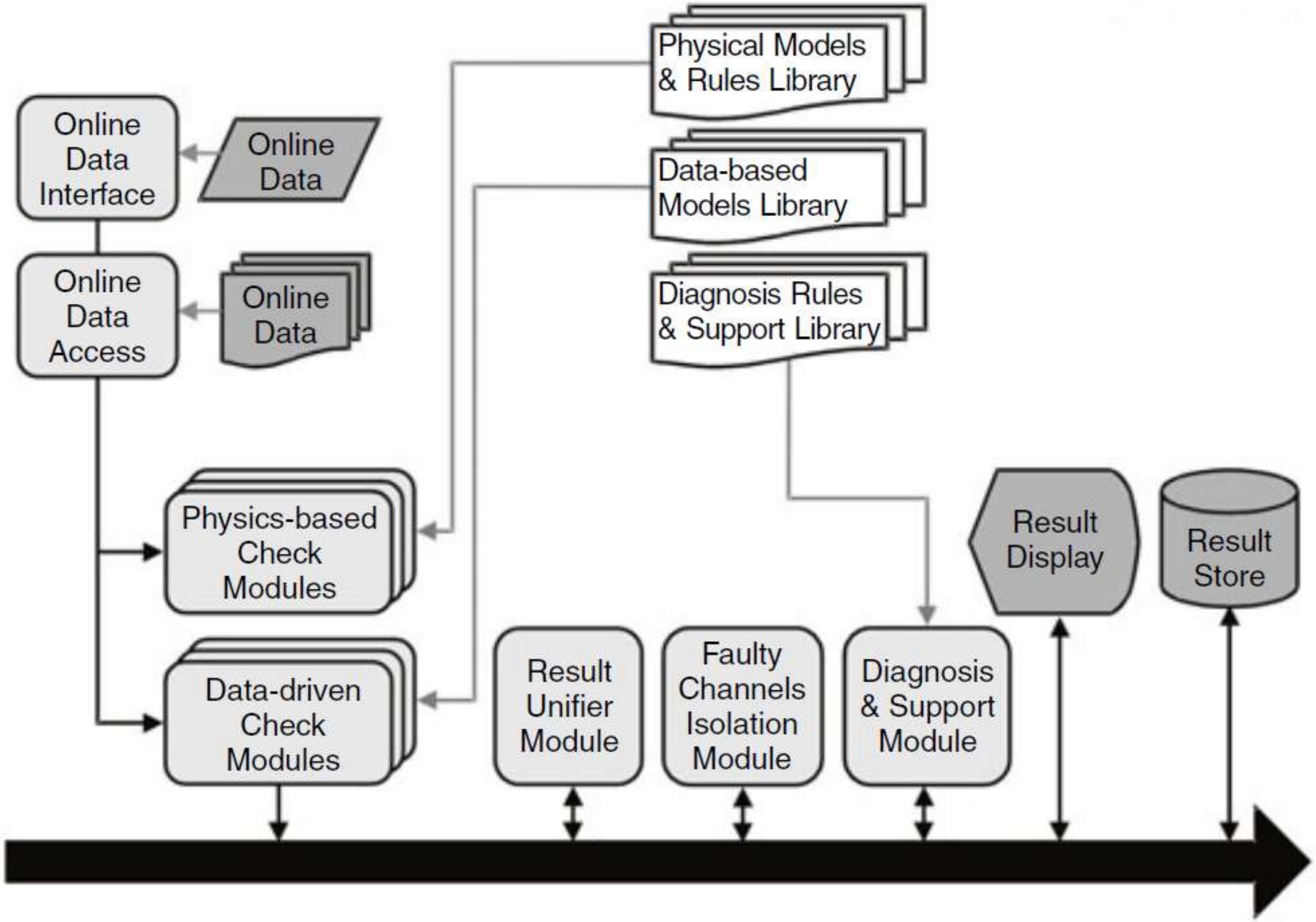
Co-funded by the Erasmus+ Programme of the European Union

Control Systems



Layout

Control Systems



Plausibility check of measured and calculated data

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8. Building Equipment

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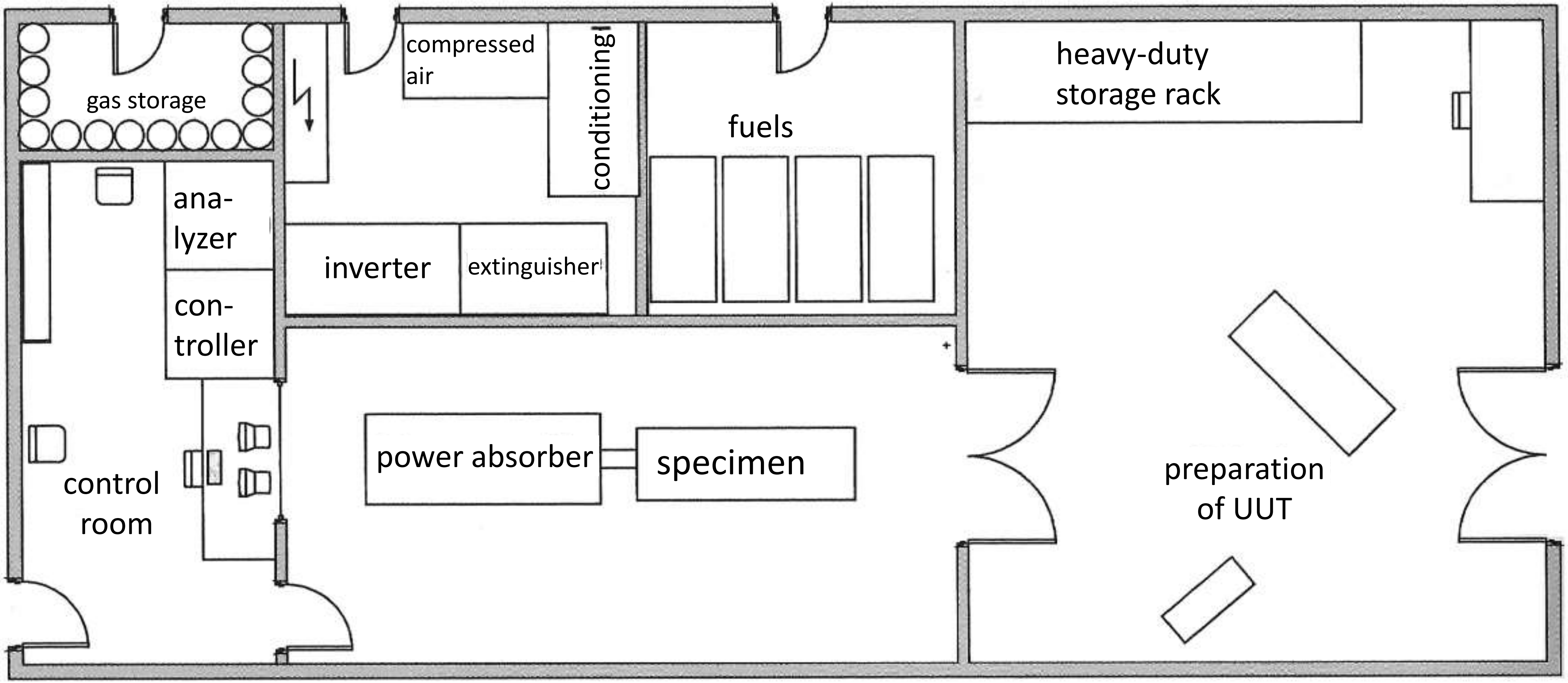
Floor Plan



Additional: Support workshop, office space for staff

Floor Plan

Cell sizing

→ Cramped cell: source of danger and inconvenience
→ too large a cell: prone to be misused as storage space

- rule of thumb: Unobstructed walkway 1 m wide, all round the rigged UUT (consider: regular calibration!)
- cell height: 4 – 4.5 m (consider: crane? Fuel-weigher?)

Dimensions l×w×h	Power Absorber	Cell Purpose
6.5 × 4 × 4	eddy-current dyno	small automotive diesels
7.8 × 6 × 4.5	AC dynamometer	ECU development for 250 kW engines, cell containing workbench and some emission equipment
9 × 6 × 4.2	2 dynos in T configuration	Engine and transmission development

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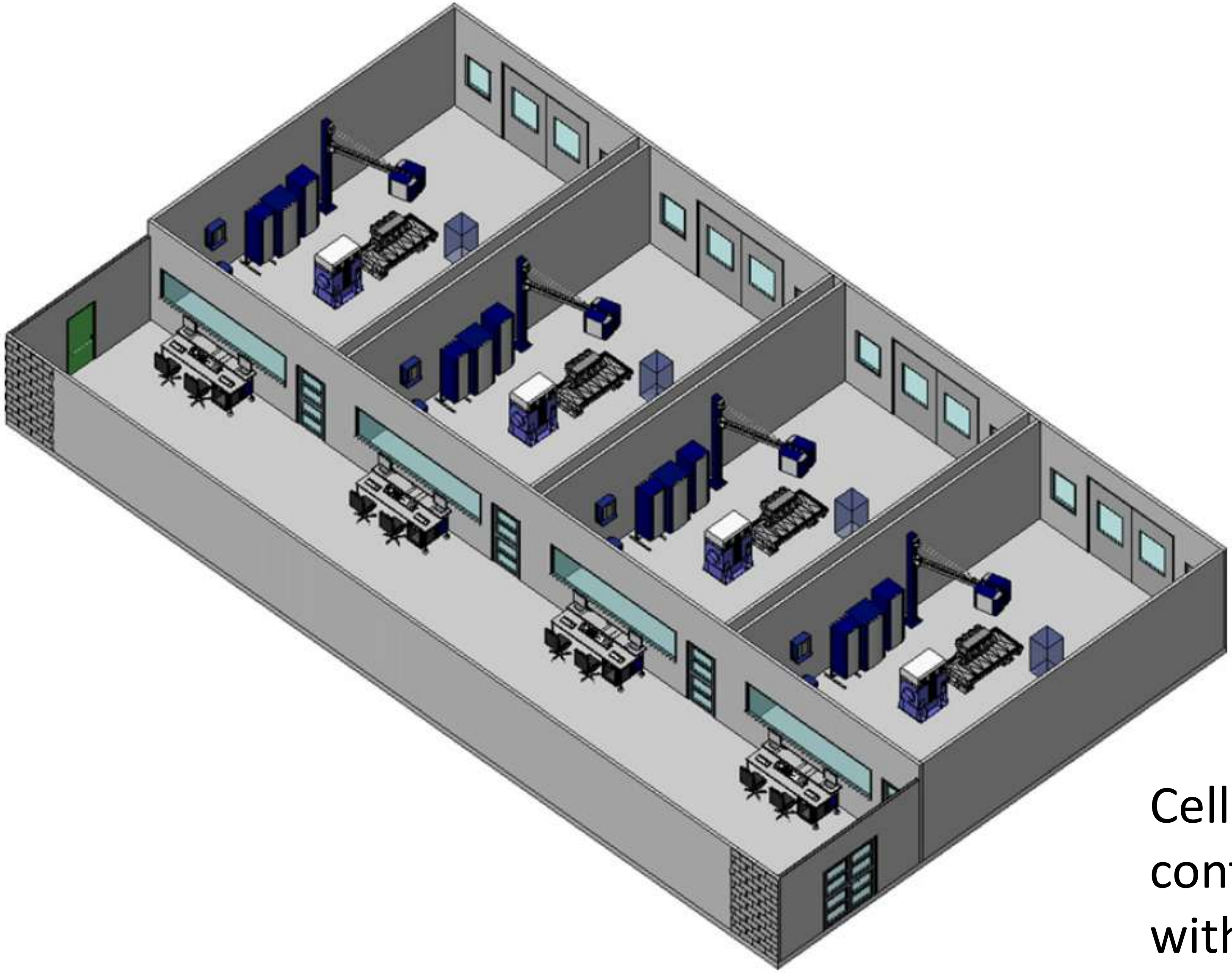
Floor Plan



Cells arranged with a common control corridor at the front and with engine access at their rear

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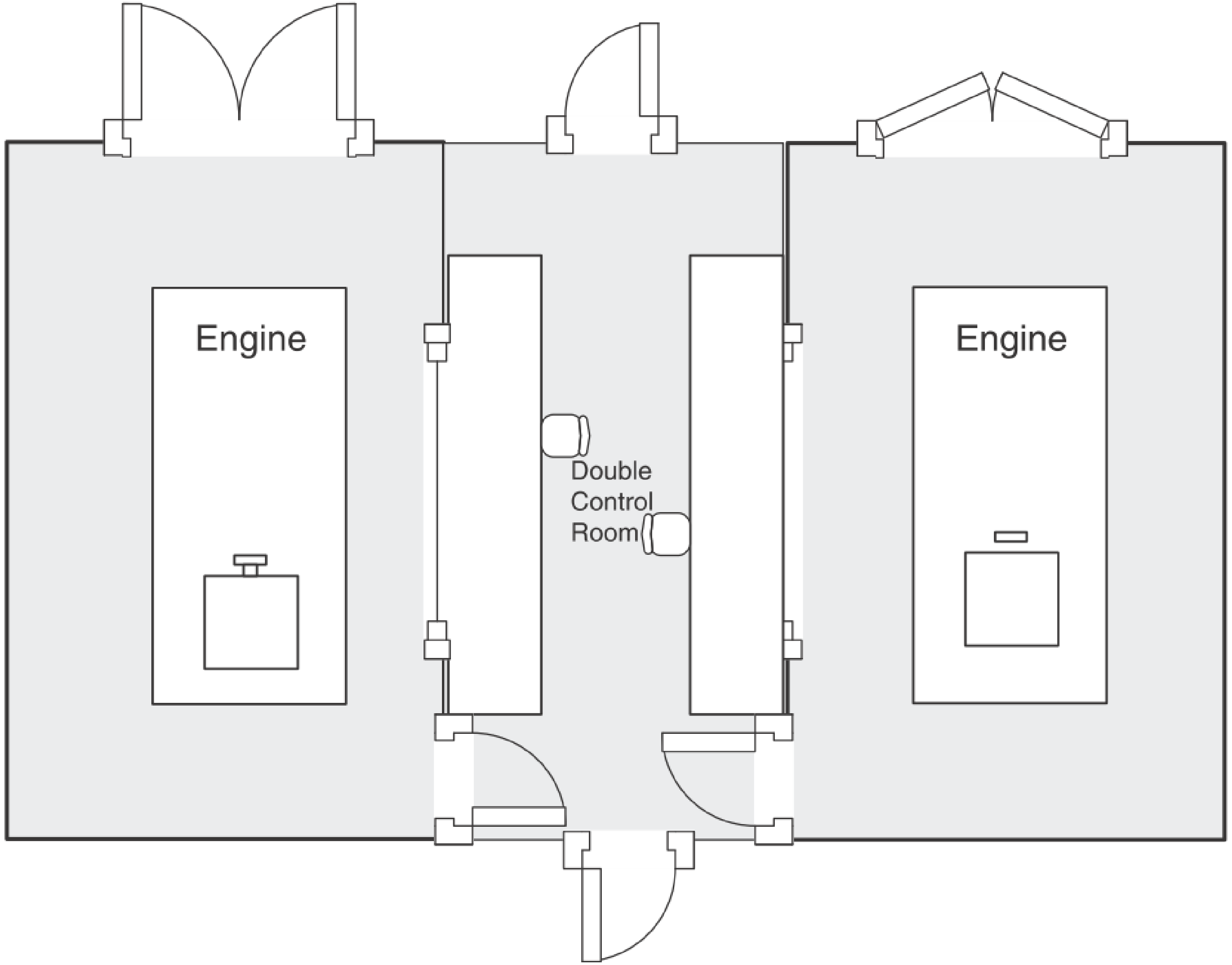
Floor Plan



"Back-to-back" control room arrangement between two cells. Engines and operator access can be kept quite separate.

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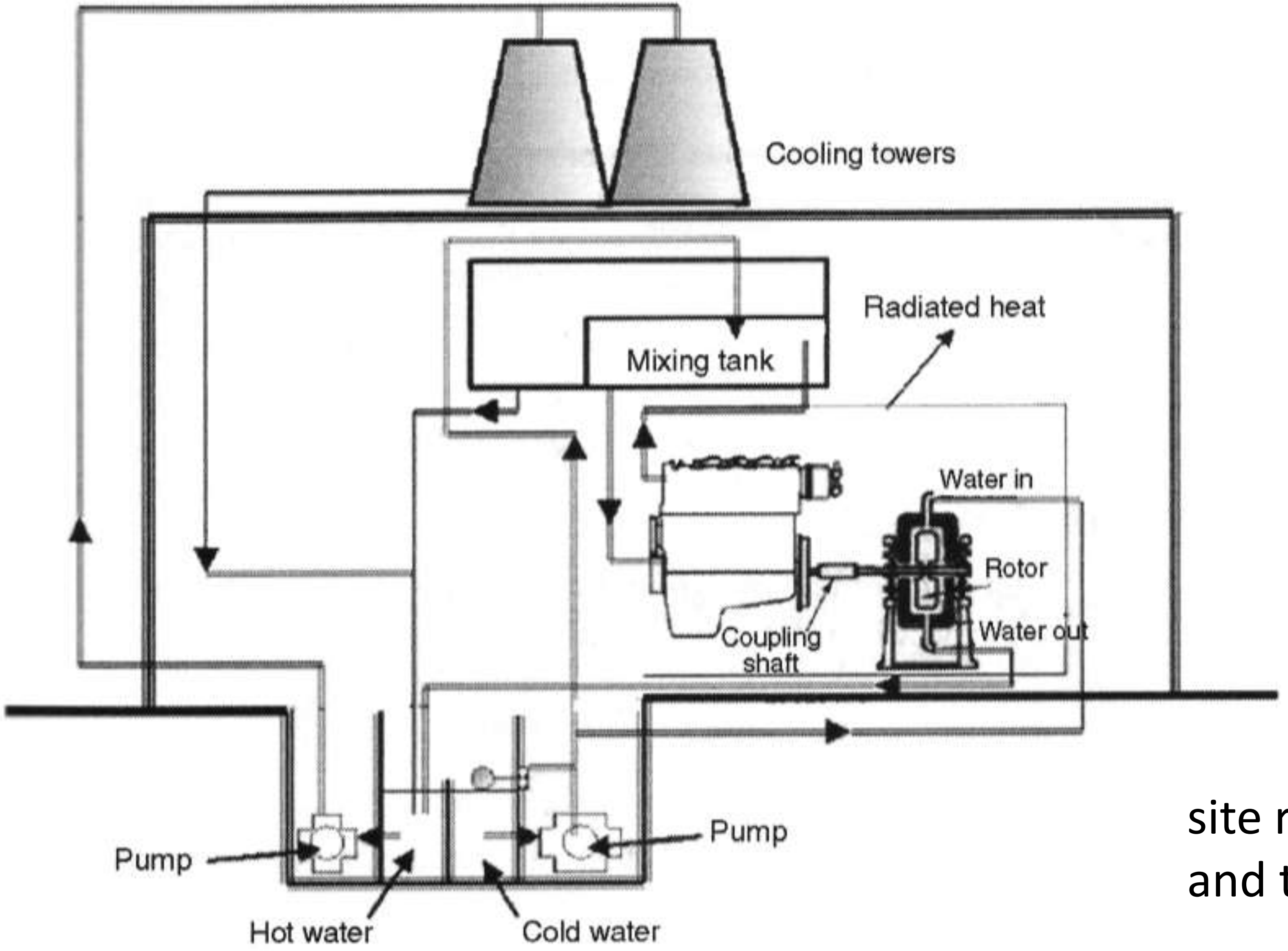
Raw Water Services



site raw water distribution and test cell schematic

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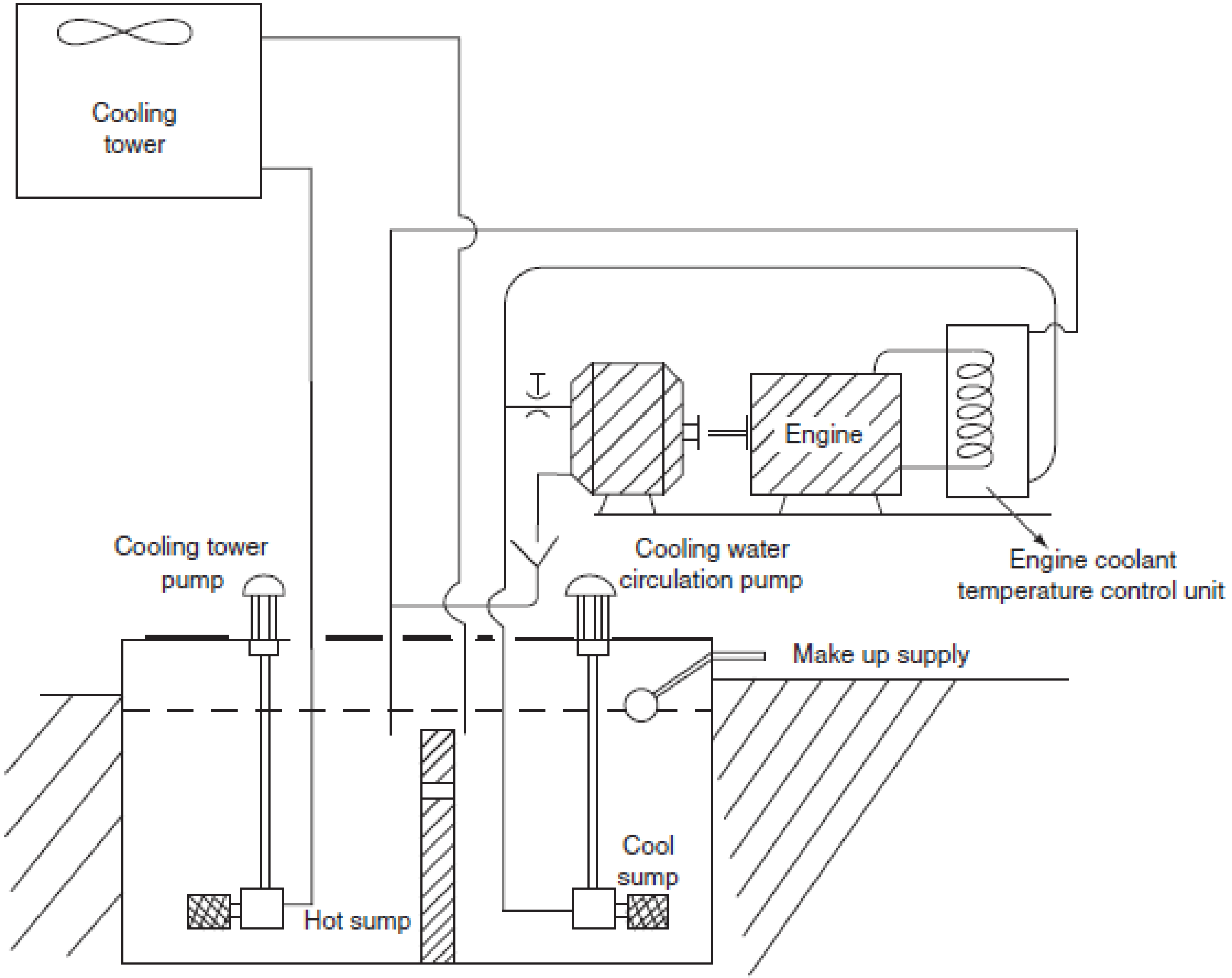
Raw Water Services



Simple open cooling water system incorporating a partitioned sump

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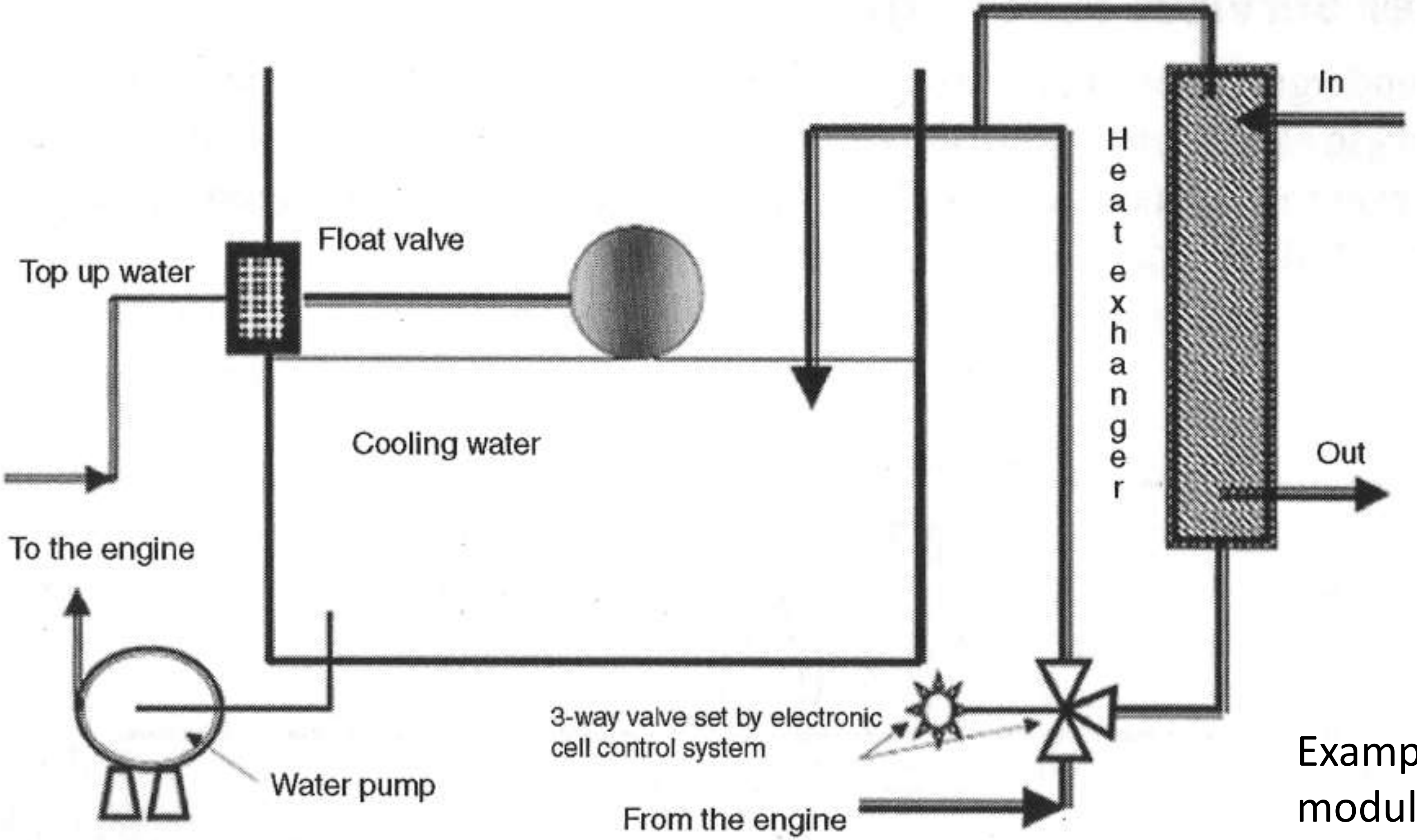
Raw Water Services



Example of a cooling water service module with a heat exchanger

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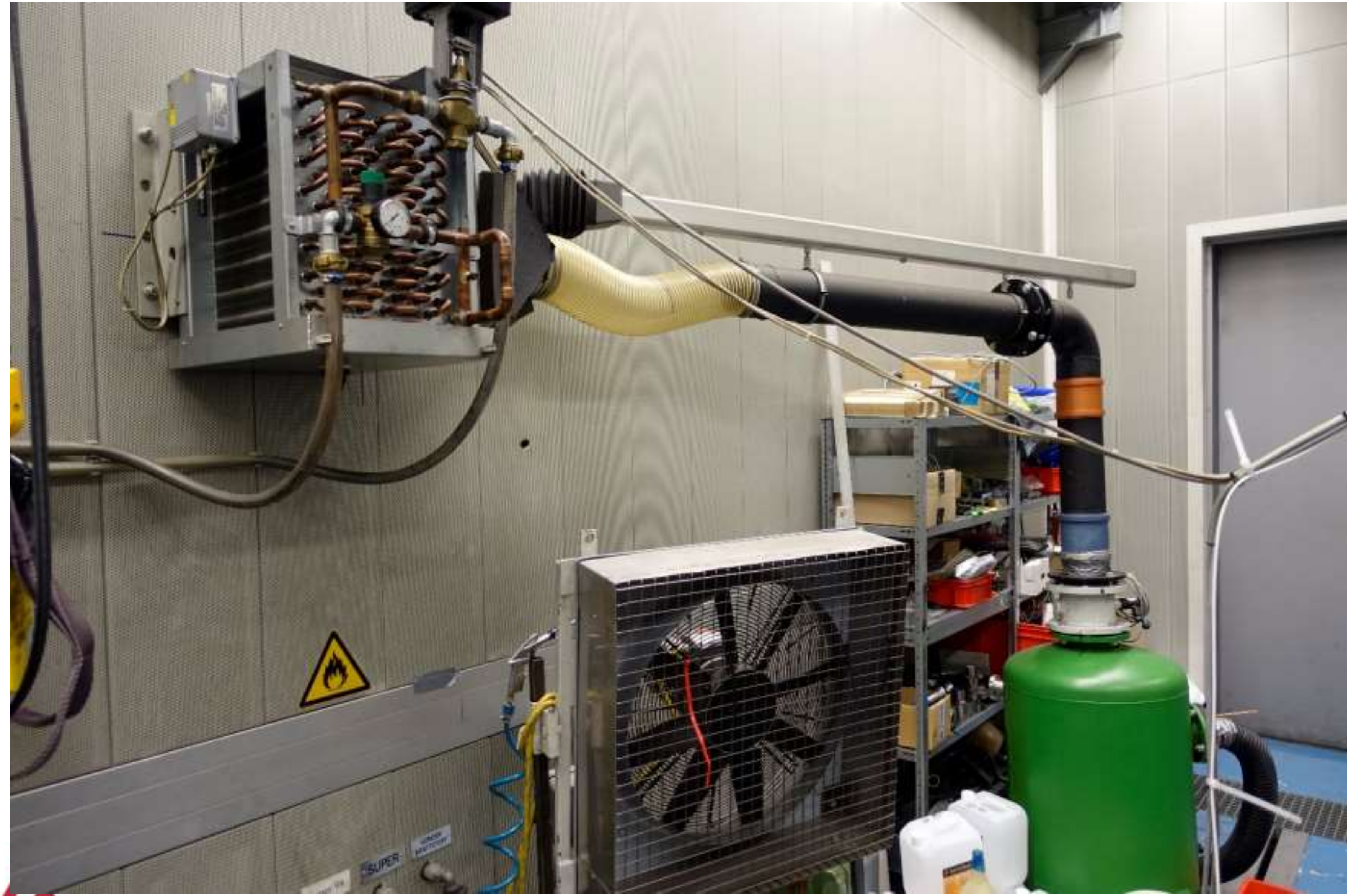
Air Supply



Conditioning
Combustion air treatment

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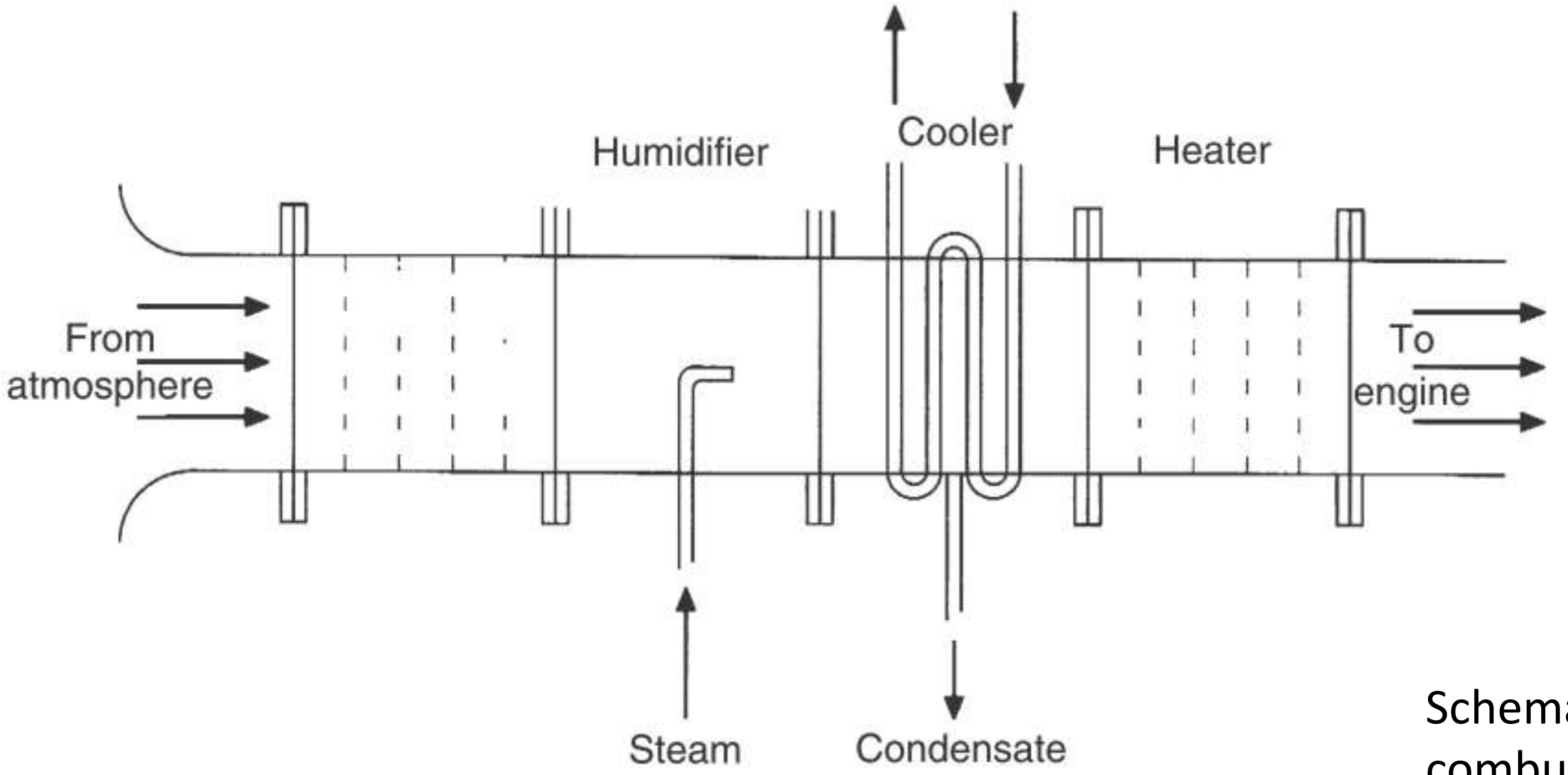
Air Supply



Schematic of typical combustion air system contents

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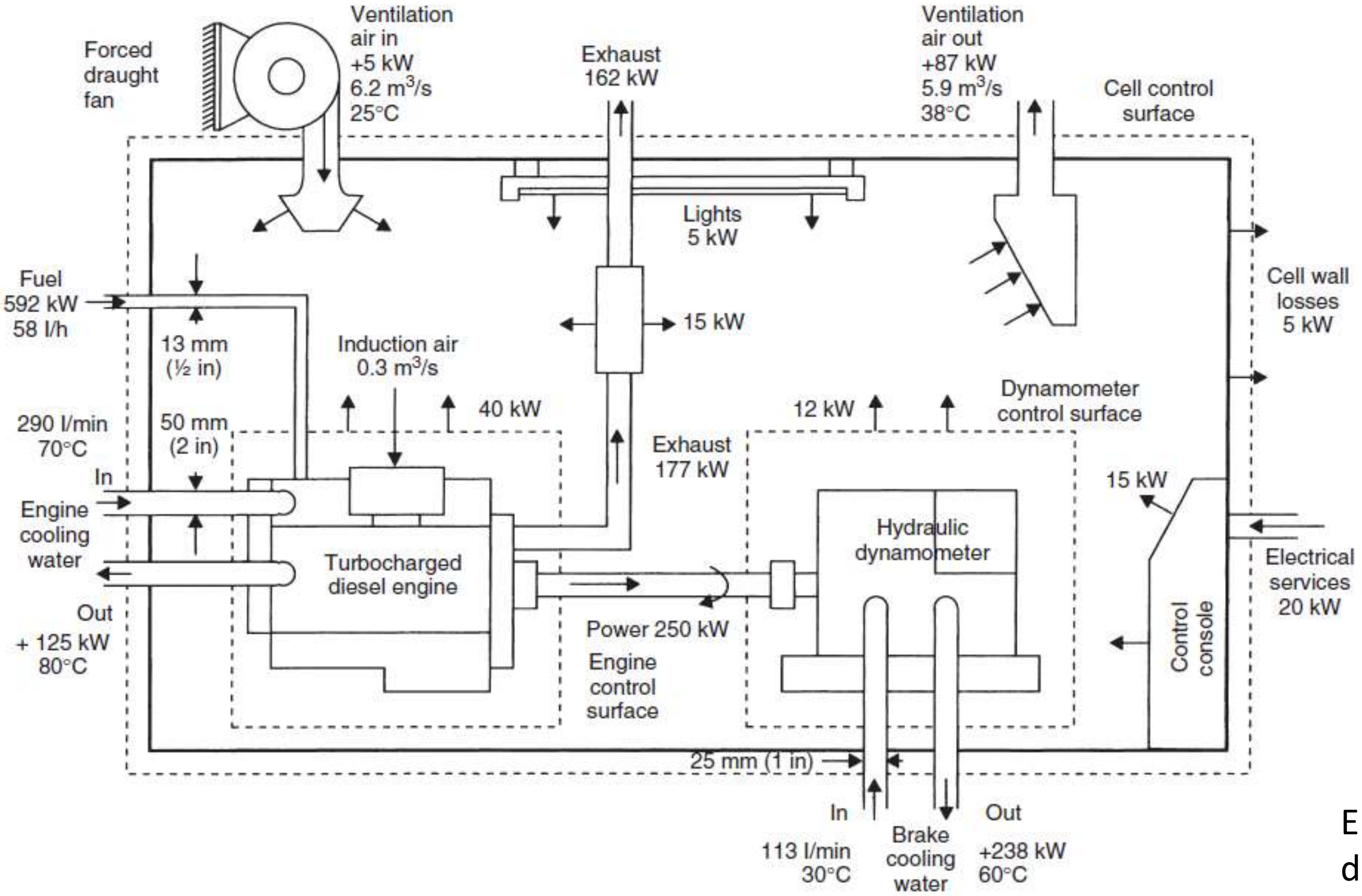
Energy Balance



Energy balance and energy flow diagram for example 250 kW cell

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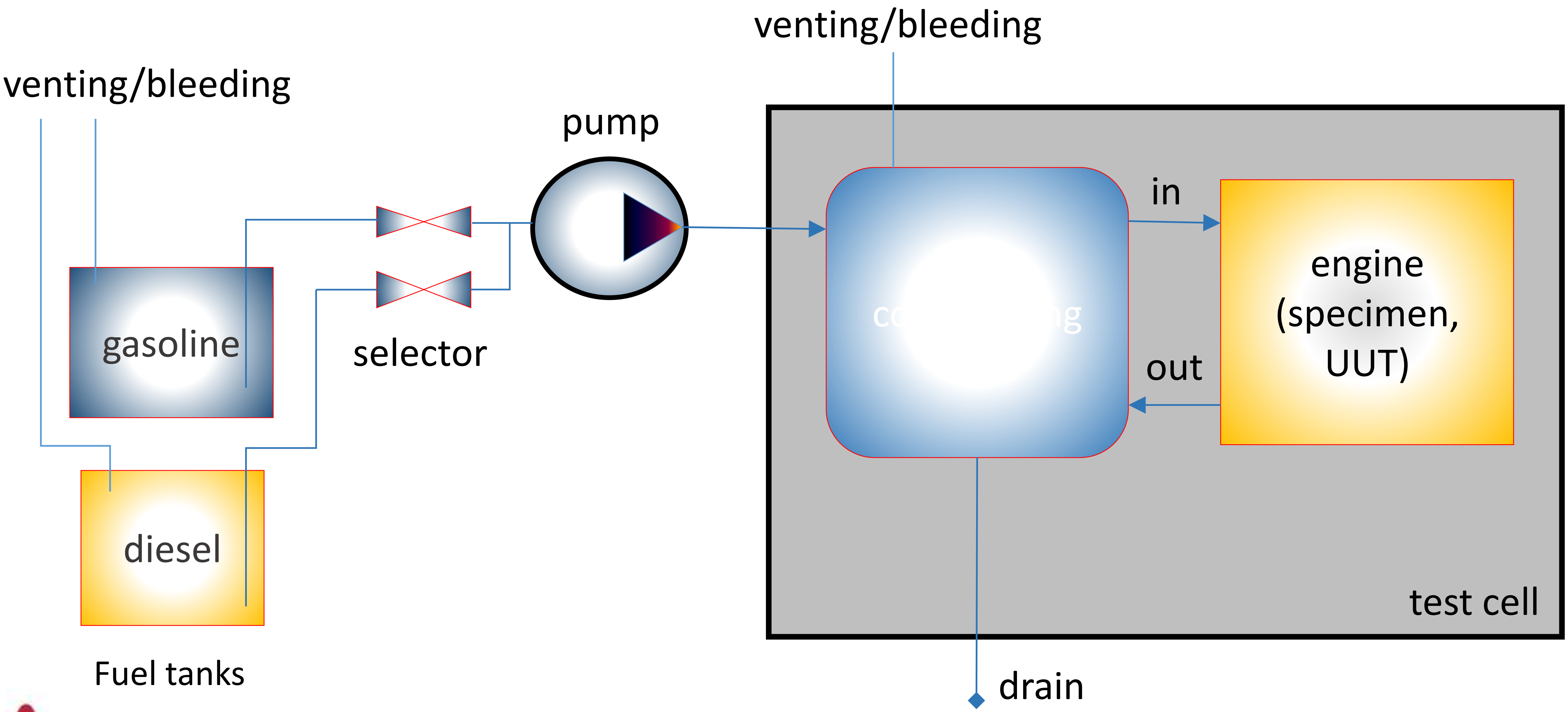
Fuel Supply



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Fuel and Oil Storage

When planning the construction or modification of any bulk fuel storage facility it is absolutely vital to contact the responsible local official(s) early in the process, so that the initial design meets with concept approval.

Many of the rules and the licensing practices imposed on bulk fuel storage are designed to cover large farm (agricultural) or transport company diesel fuel systems and retail filling stations.
Test facilities that only handle fuel within a closed (reticulation) pipe system may not fall under such rules.

Most important reference legislations:

- The Petroleum (Consolidation) Act 1928
- The Health and Safety at Work etc. Act 1974
- Dangerous Substances and Explosive Atmospheres Regulations in 2002
- ATEX Directive 94/9/EC (UK), EPA regulations (US)
- Control of Pollution (Oil Storage) (England) Regulations 2001.

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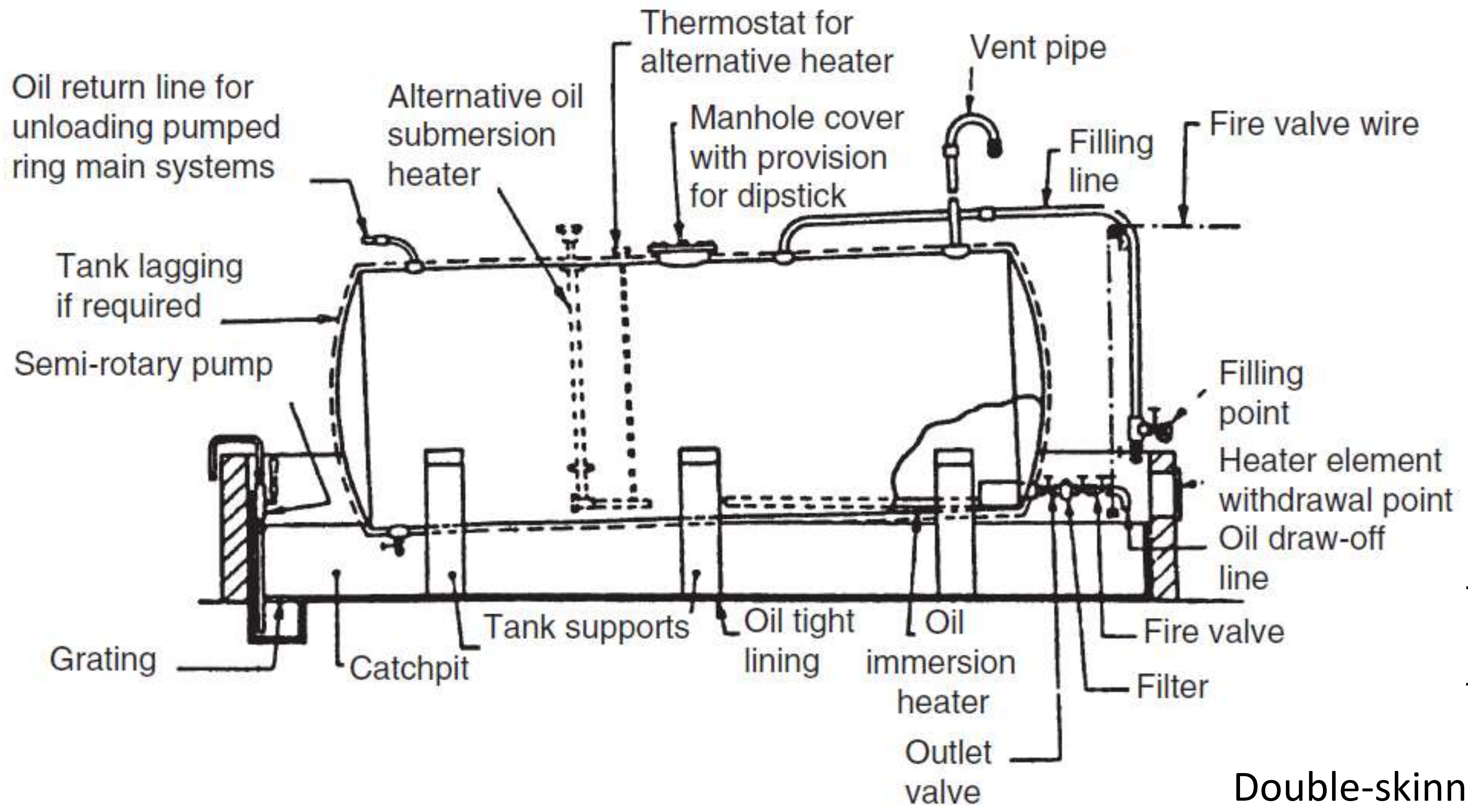
Fuel and Oil Storage



Typical above-ground bunded fuel tank with fittings

Double-skinned tank recommended

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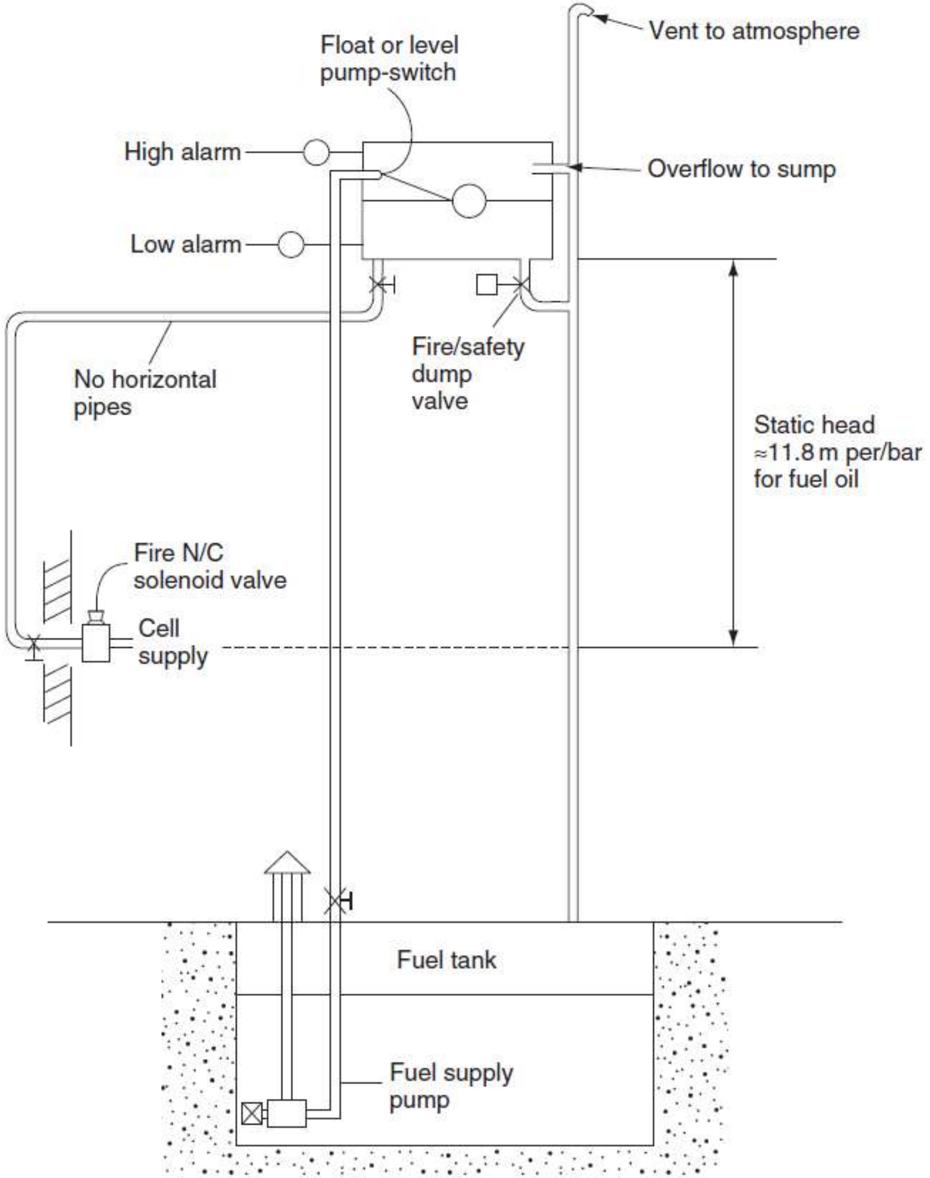
Fuel and Oil Storage



The static head is commonly at 4.5 m or above, but may need to be calculated specifically to achieve the 0.5–0.8 bar inlet pressure required by some industrial standard fuel consumption and treatment instruments.

A schematic showing the elements of a typical fuel day-tank system, in this case combined with a subterranean bulk tank

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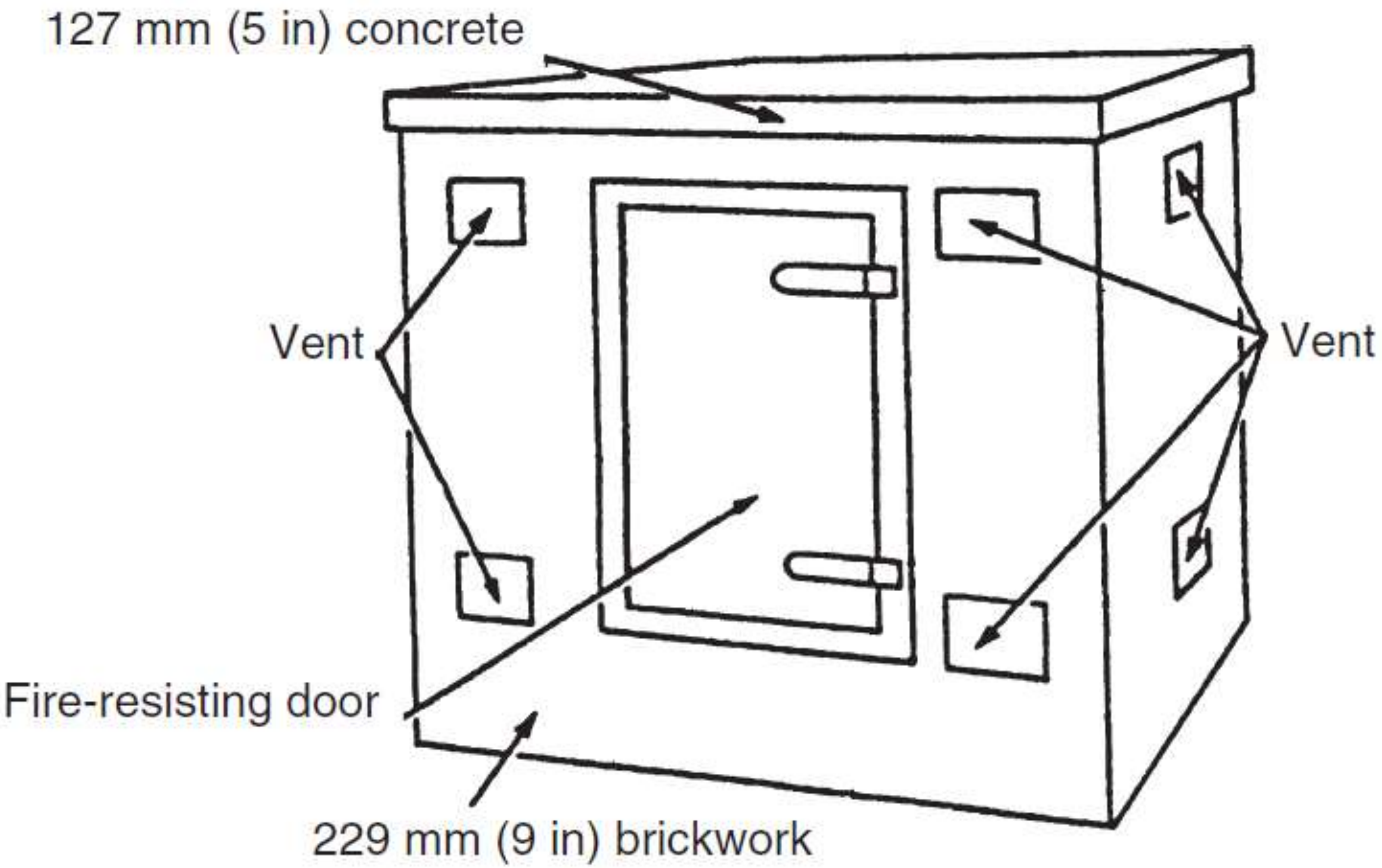
Fuel and Oil Storage



Design of fuel drum store, minus statutory warning signs

Fuel Storage

Fuel drum store, inside

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Fuel Supply

Test cell connection

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Fuel Pipes

Above-ground Fuel Pipes

- Can be seen
- Can not be accidentally damaged
- Made of drawn steel tubing, stainless steel

Underground Fuel Pipes

- Buried fuel lines are required to be of a double-walled design with the facility to check leakage from the primary tube into interstitial space (interstitial monitoring).
- Double-walled pipe systems are made of extruded high-density plastics with the outer sleeve composition chosen for high abrasion resistance and the inner sleeve composition for very low permeability to fuels.
- Such pipes and fittings have to be electrofusion welded,
  have a maximum pressure rating for the inner containment sleeve of 10 bar,
  and a 30-year minimum design life.

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Fuel Storage

Remember: VICES

V = ventilation. Adequate ventilation rapidly disperses flammable vapours.

I = ignition. All ignition sources should be removed from fuel handling areas.

C = containment. The fuels must be held in containers suitable for their containment with secondary devices such as trays to catch spillage and absorbent materials to hold and clean up any leakage.

E = eliminate. Is it possible to eliminate or reduce some of the fuel containment?

S = separation. Fuels should be stored in areas well separated from other storage or work areas or areas where they are exposed to accidental damage (delivery trucks, etc.).

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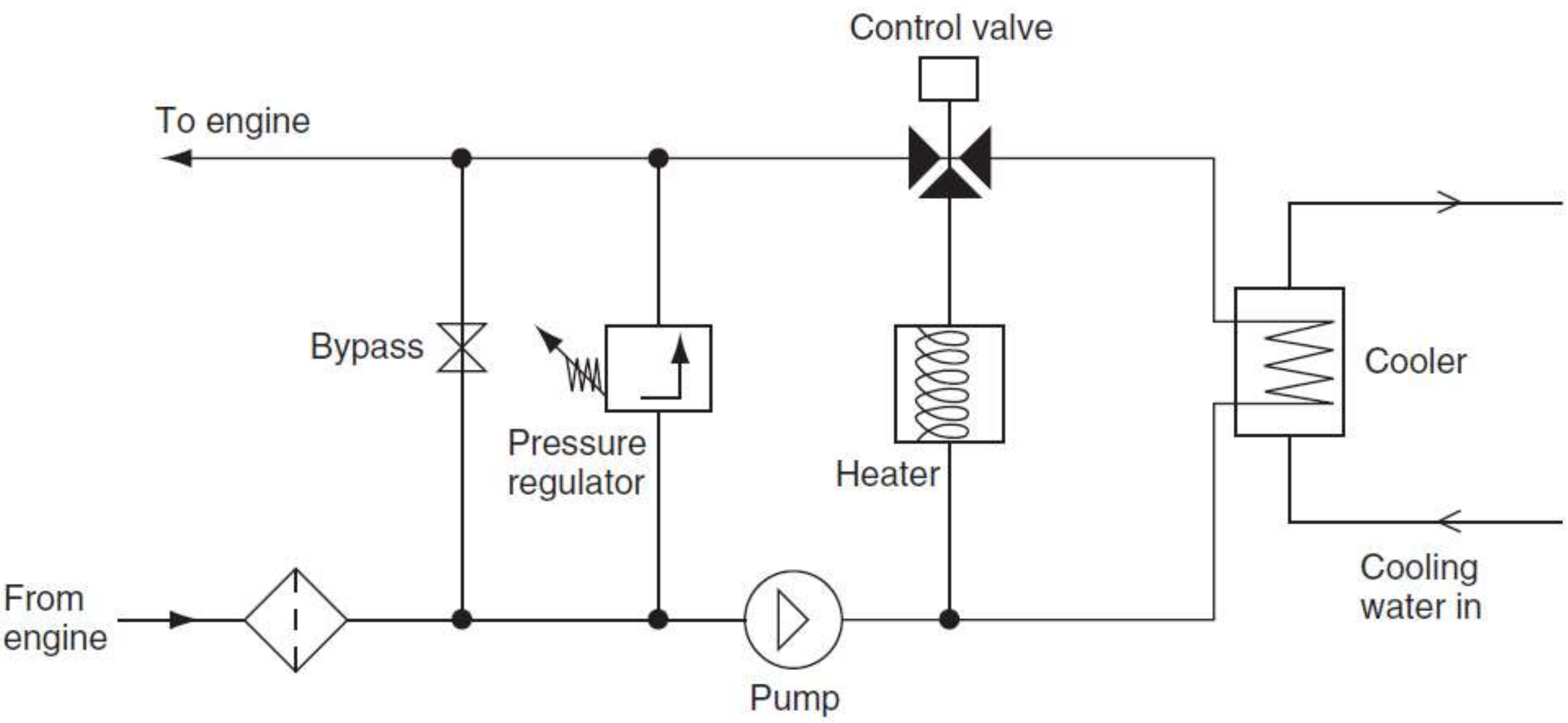
Oil Conditioning System



Schematic of oil temperature control unit, sensing points and control connections omitted

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Auxiliaries

Gas storage
in 20-foot ISO
shipping container
(cost-effective
solution)

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Auxiliaries

Calibration gases:

Zero gas

- Synthetic air (SL) for FID (burner air)
- Nitrogen (N_2) for NDIR and CLD

Span gas

- Propane (C_3H_8) in synthetic air for FID
- CO or CO_2 in nitrogen for NDIR
- NO in nitrogen for CLD
- Nominal value must be within 80 and 95% of full scale
- Concentration must not differ from nominal value by more than ± 2%

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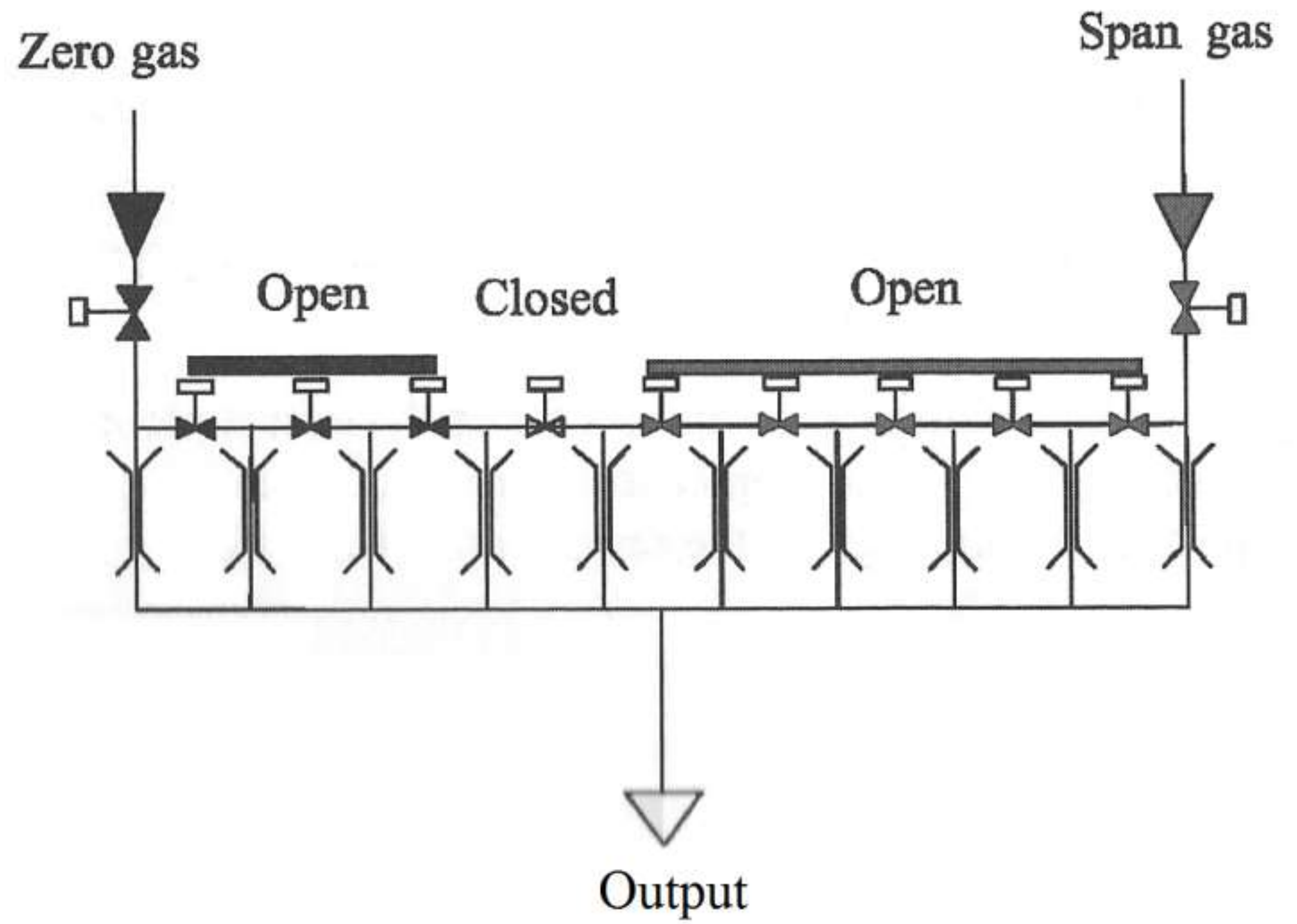
Auxiliaries



Gas divider

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Auxiliaries

Compressed air
(shop air)
Pumps

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Auxiliaries

Frequency inverters

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Auxiliaries

Air conditioning unit
Blower

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Auxiliaries

Crane beams useful for (hopefully rare) maintenance and used as „sky hook“.
But automotive engines are rigged on trolley systems – cost/benefit calculation does not justify installation.
But wall of cells have to strengthened.

Overhead crane
Lifting beam
Sensor box

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Auxiliaries

Connectors,
fittings,
pipes, hoses

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Layout of Test Chambers

4th Training in Rio de Janeiro, BRA

6th-9th of May 2019

Michael Trzesniowski

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