

Design of Process Equipment

P&ID and Measurement and Control

Lecture

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Bratislava, February 2024

Introduction

The most important document of the process unit design

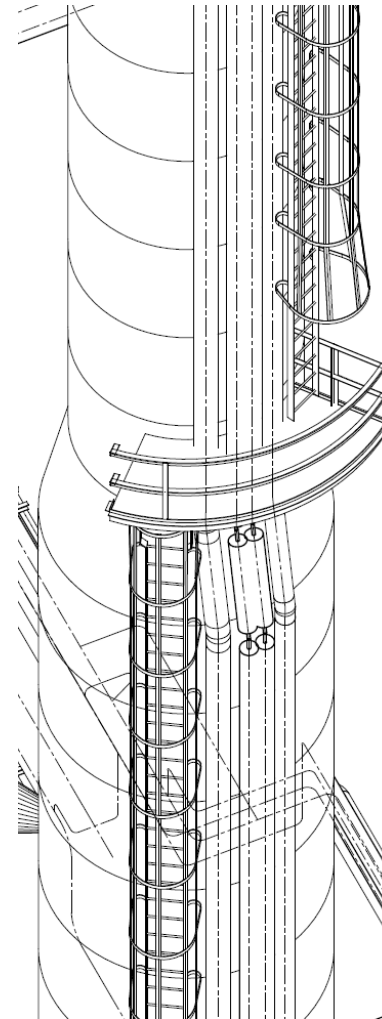
P&ID Piping and Instrumentation Drawing /Diagram/

It is the key document for all other project drawings and documents.

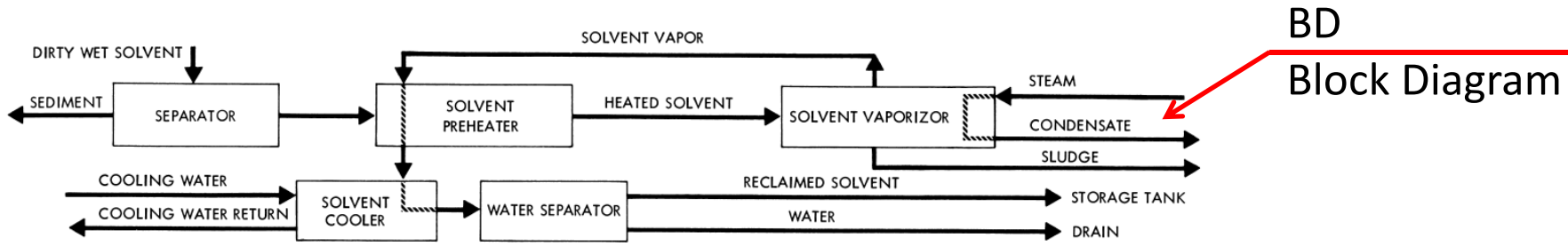
It is based on a technological scheme (PFD – Process Flow Diagram).

PFD – schematically shows the process with the representation of the main flows.

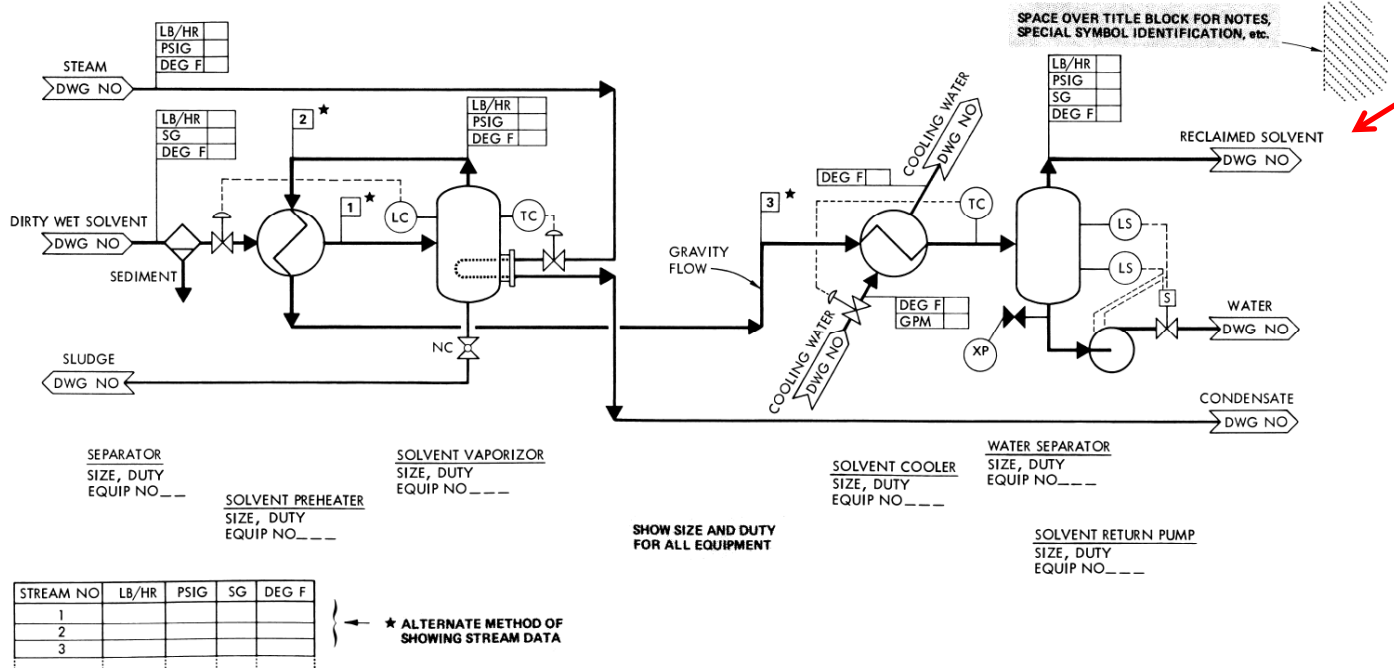
It determines the material and energy balance for the proposed production.



From BD to ... PFD and P&ID

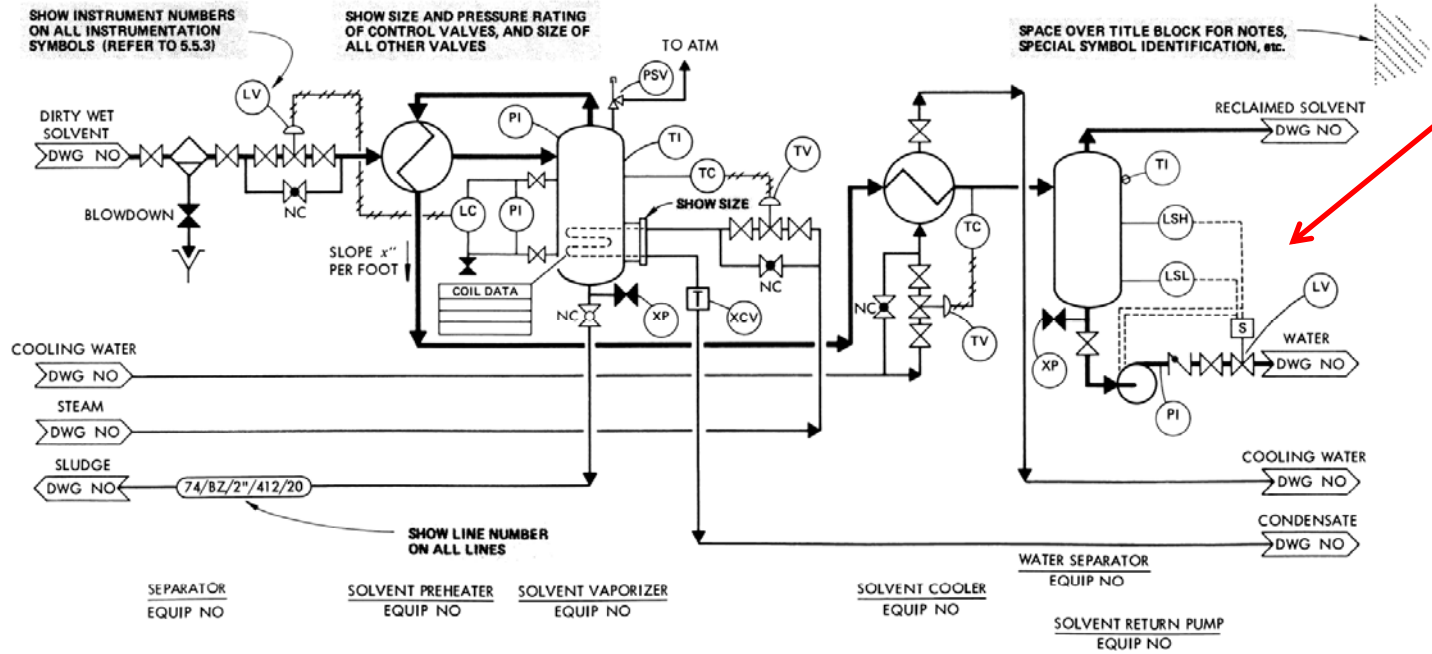


BD
Block Diagram

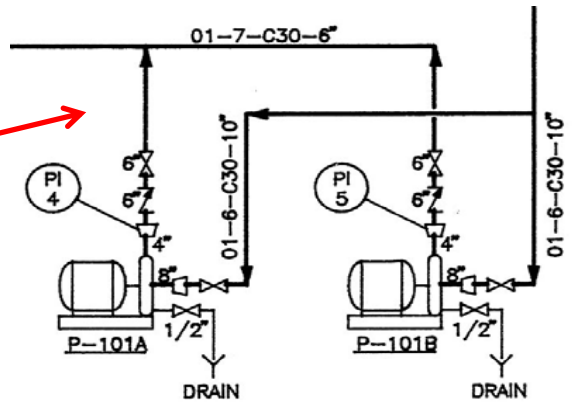
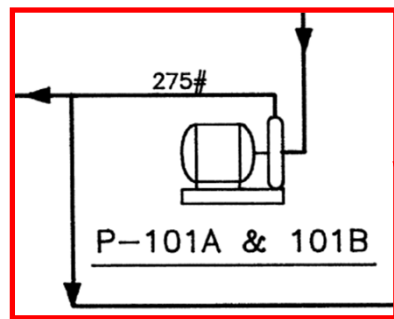


PFD
Process Flow Diagram

From BD to ... PFD and P&ID



P&ID
Piping and Instrumentation Diagram



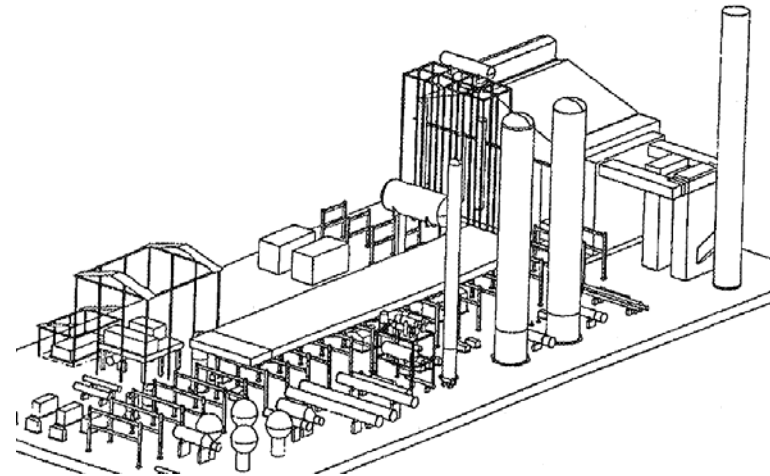
P&ID

P&ID (Piping and instrumentation diagram) shows the mutual pipe connection between process apparatuses and devices together with the control system.

All professions participate in its preparation:

- technologist,
- mechanical engineer,
- security technician,
- specialists etc.
- electrician
- automation

It represents a detailed processing of the entire technology

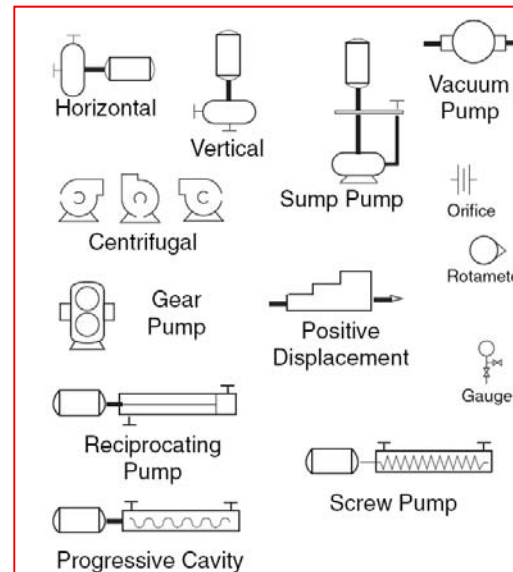


P&ID

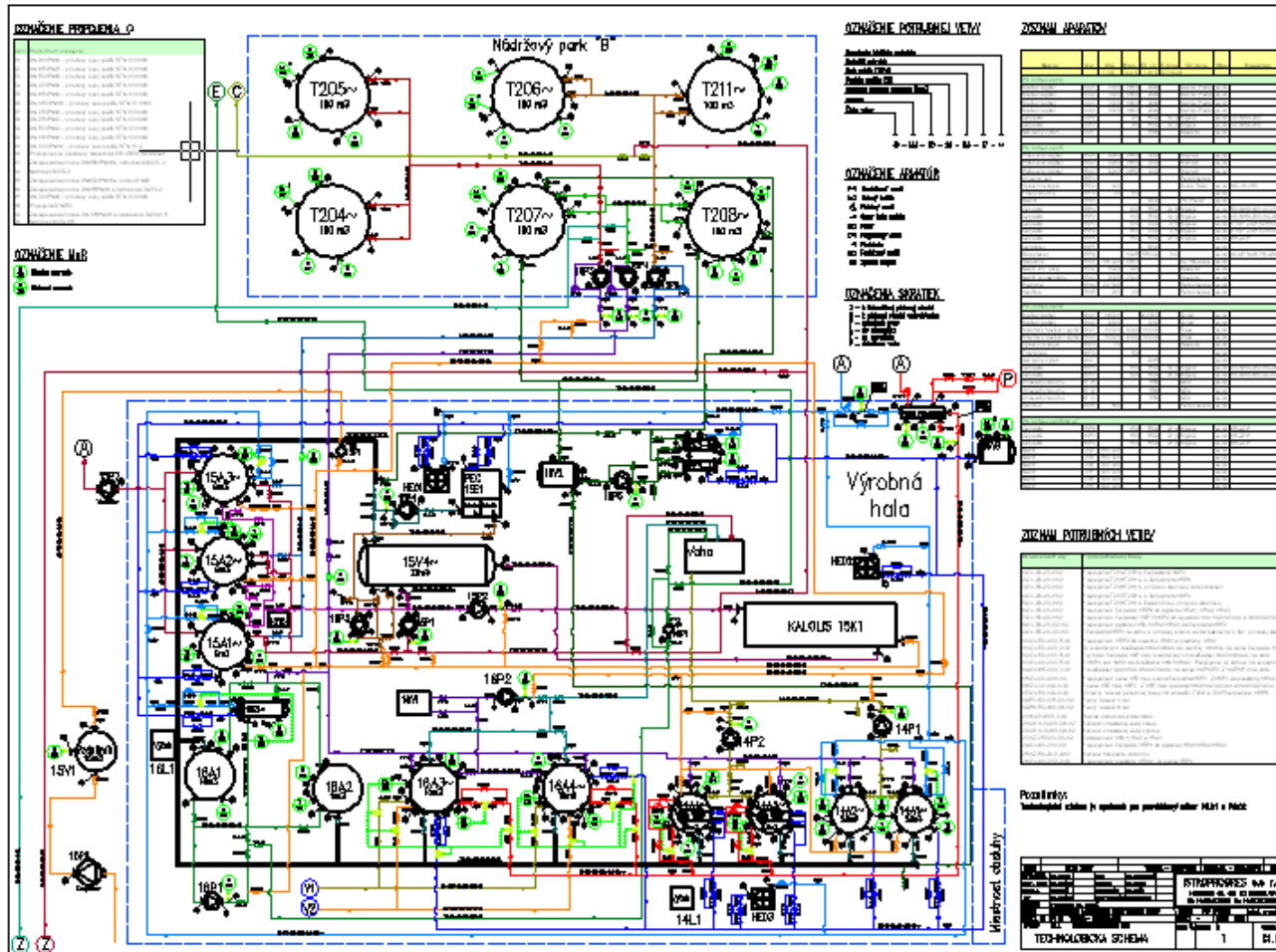
VALVE SYMBOLS	EQUIPMENT CONT.	LINE SYMBOLS
		<p>Future Equipment ----- Major Process ----- Minor Process ----- Pneumatic ----- Hydraulic ----- Capillary Tubing ----- Mechanical Link -----</p> <p>Electromagnetic, Sonic Optical, Nuclear Electric -----</p> <p>Connecting Line ----- Non-Connecting Line ----- Non-Connecting Line ----- Jacketed or Double Containment ----- Software or Data Link -----</p>
EQUIPMENT SYMBOLS		INSTRUMENT SYMBOLS
		<p>TI Temp. Indicator FI Flow Indicator TT Temp. Transmitter FT Flow Transmitter TR Temp. Recorder FR Flow Recorder TC Temp. Controller FC Flow Controller LI Level Indicator PI Pressure Indicator LT Level Transmitter PT Pressure Transmitter LR Level Recorder PR Pressure Recorder LC Level Controller PC Pressure Controller FE Flow Element I/P Transducer TE Temperature Element PIC Pressure Indicating Controller LG Level Gauge PRC Pressure Recording Controller AT Analyzer Transmitter LA Level Alarm</p>
		<p>APPROVED <i>C. Thomas</i> PCE DATE 10-6-99</p> <p>GENERAL LEGEND DISTILLATION UNIT</p> <p>DRAWING NUMBER OO6543</p> <p>REVISION 1 PAGE 1 OF 30</p>
PREFIXES	ABBREVIATIONS	
CW- cooling water RX- reactor MU- makeup UT- utilities FW- feed water CA- chemical addition SE- sewer IA- instrument air	D- drum TK-tank P- pump C- column F- furnace V- valve CT- cooling tower EX- exchanger	

P&ID - Piping and instrumentation diagram

-different interpretation other standards, norms, customs...there are developed comprehensive recommendations, company standards (a mix of standards, recommendations, customary designations... etc.)



P&ID

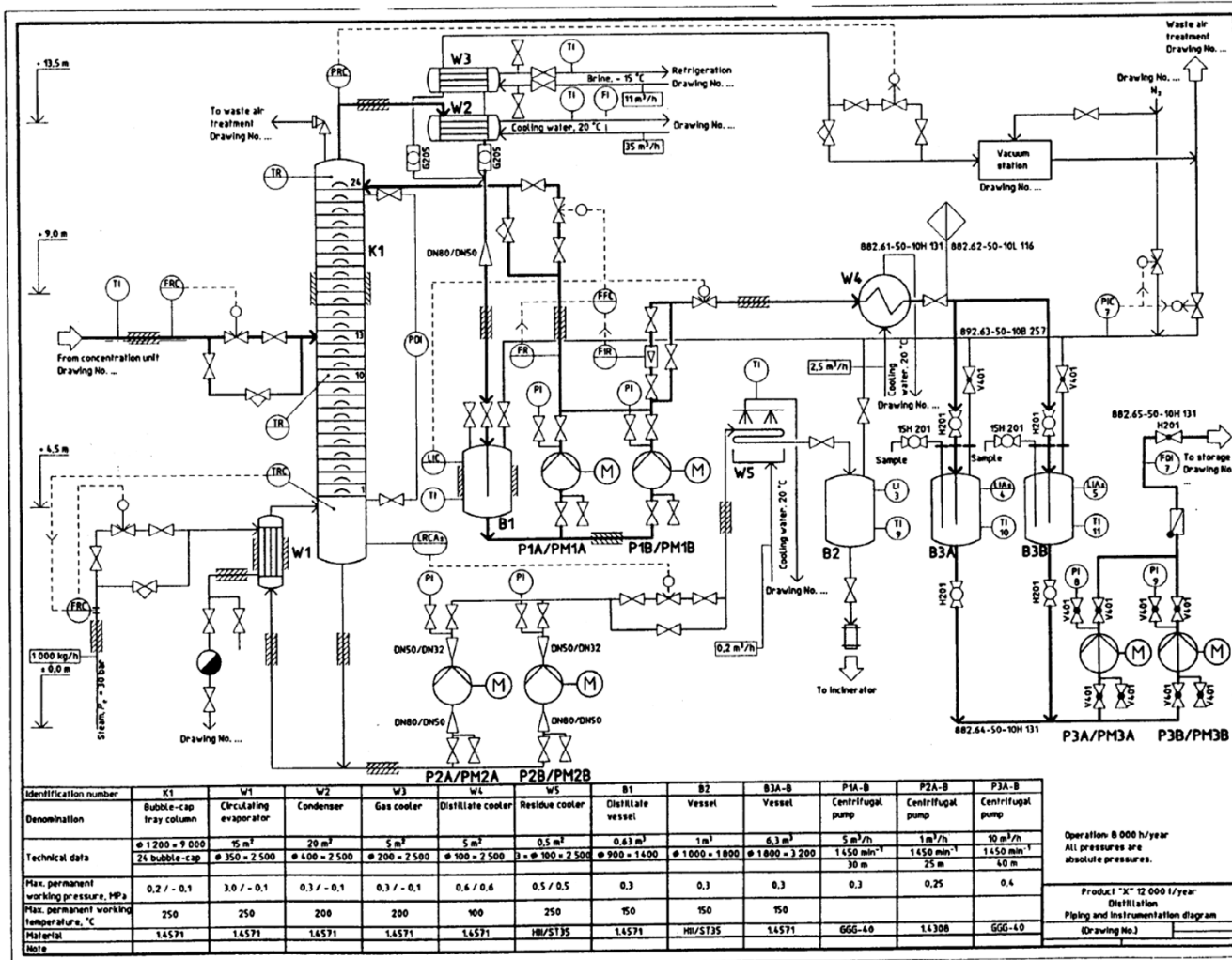


P&ID - Piping and instrumentation diagram

shows the mutual piping connection between the process apparatus and equipment together with the control system.

What must it contain?

P&ID



P&ID - Piping and instrumentation diagram

P&ID

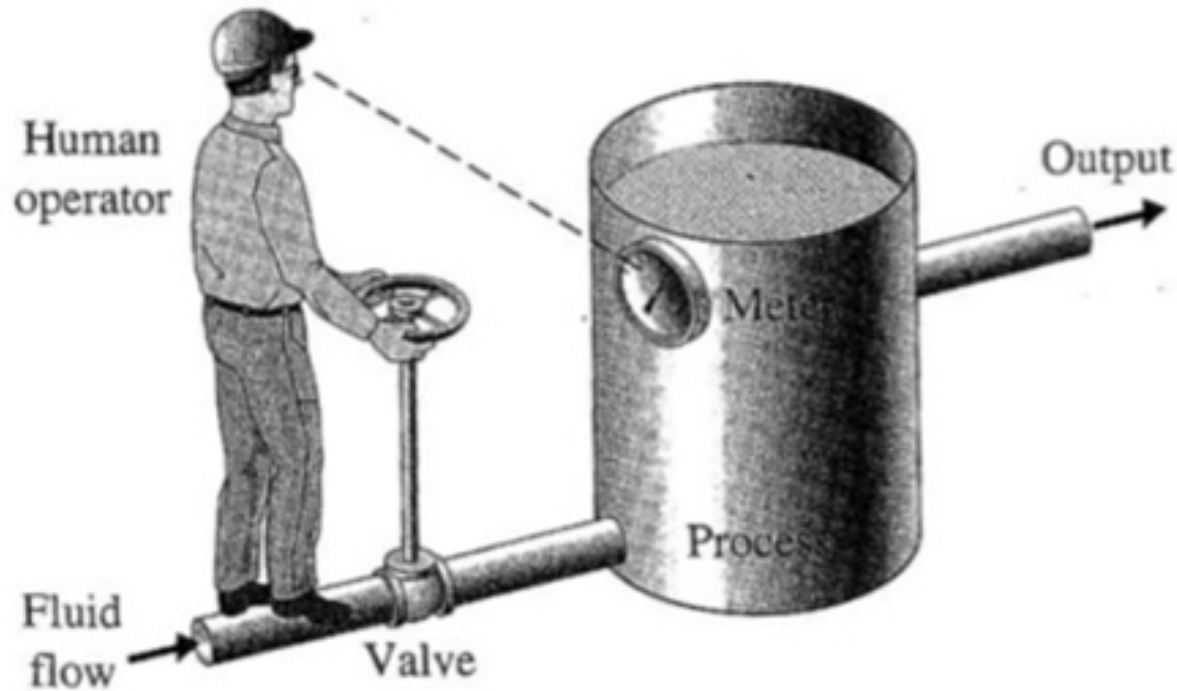
FLOW LINES	LINE SYMBOLS	STRAINERS	TANK EQUIPMENT	EQUIPMENT	PIPING TAGS																																																																																																																																																																																																									
<p>MAJOR FLOW LINE</p> <p>MINOR FLOW LINE</p> <p>236 INSULATION</p> <p>237 TRACING AND INSULATION</p> <p>235 DIRECTION</p> <p>239 HOSE</p> <p>238 LINE BREAK</p>	<p>224 DETONATION ARRESTOR (DA)</p> <p>225 FLAME ARRESTOR (FA)</p> <p>226 FLAME ARRESTOR BI-DIRECTIONAL (FA)</p> <p>229 WATER SEPARATOR (WA)</p> <p>228 WATER SEPARATOR (WA)</p> <p>227 SIGHT GLASS (SG)</p> <p>227 BELLOW (X)</p> <p>228 COMPENSATOR (X)</p> <p>229 STEAM TRAP</p> <p>228 AUTOMATIC VENTILATION</p> <p>229 FUNNEL</p> <p>228 HYDRANT (H)</p> <p>229 PIG TRAP (PTR)</p> <p>228 EJECTOR (J)</p> <p>228 DOSING NOZZLE</p> <p>228 SLOPE</p> <p>227 SPEC. BREAK HOR</p> <p>228 SPEC. BREAK VER</p> <p>229 UG - UNDER GROUND</p> <p>228 AG - ABOVE GROUND</p> <p>228 LOCATIE CODE VER</p> <p>228 LOCATIE CODE HOR</p> <p>229 TELESCOPIC PIPE (TCP)</p>	<p>231 Y-TYPE STRAINER (YS)</p> <p>230 STRAINER (SI)</p> <p>231 BASKET-TYPE STRAINER (BS)</p> <p>232 TEMPORARY STRAINER (TS)</p> <p>CAPS</p> <p>231 HOSE CONNECTION</p> <p>232 PIPE CAP</p> <p>REDUCERS</p> <p>233 CONCENTRIC REDUCER</p> <p>234 ECCENTRIC REDUCER</p> <p>ROTATING EQUIPMENT</p> <p>236 IN LINE PUMP (PI)</p> <p>237 LOBE PUMP (PI)</p> <p>236 LIQUIDRING PUMP (PI)</p> <p>239 DIAPHRAGM PUMP (PI)</p> <p>270 CENTRIFUGAL PUMP (PI)</p> <p>271 SCREW PRESS PUMP (PI)</p> <p>272 GEAR PUMP (PI)</p> <p>273 COMPRESSOR (PI)</p> <p>274 BLOWER (PI)</p> <p>275 DEEP WELL PUMP (PDW)</p>	<p>274 MIXER (IMX)</p> <p>270 SAMPLE POINT</p> <p>271 MEASURING POINT</p> <p>274 COIL</p> <p>270 THERMAL HEATER</p> <p>270 SUCTION NOZZLE</p> <p>270 JET NOZZLE</p> <p>280 GROUNDING</p> <p>281 FOAM MAKER (IFM)</p> <p>280 SPRINKLER</p> <p>280 MAN HOLE</p> <p>279 VENT WITH BIRD SCREEN (BS)</p> <p>280 VENT</p> <p>284 FREE VENT</p> <p>280 VESSEL OR DRUM (V) (D)</p> <p>275 LEAK DETECTION</p> <p>280 FOUL COVER TANK</p> <p>286 TANK WITH CONE ROOF</p> <p>287 TANK WITH UMBRELLA OR DOME ROOF</p> <p>288 TANK WITH EXTERNAL FLOATING ROOF</p> <p>289 TANK WITH INTERNAL FLOATING ROOF AND RAIN DOME (ALU)</p>	<p>283 STATIC MIXER (IMX)</p> <p>284 HEAT EXCHANGER (IE)</p> <p>285 COOLER (IC)</p> <p>284 COMPRESSED AIR DRYER (ICD)</p> <p>285 FOAM CANNON (IFC)</p> <p>286 HOSE REEL (HR)</p> <p>281 SAMPLE CABINET (ISB)</p> <p>287 CAR/RAIL LOADING ARM (LA)</p> <p>283 MARINE LOADING ARM (LA)</p> <p>284 CAROUSEL 3 (JUMPER) (ICAR)</p> <p>285 CAROUSEL 4 (JUMPER) (ICAR)</p> <p>284 CFA STORAGE VESSEL (RIM SEAL FIRE PROTECTION) (ICP)</p> <p>282 OIL SKIPPER (SK)</p> <p>283 FUEL STATION (IFUS)</p>	<p>C.S.C. CAR SEAL CLOSED</p> <p>C.S.O. CAR SEAL OPEN</p> <p>PMC FOAM CHAMBER</p> <p>F.B. FULL BORE BALL VALVE</p> <p>F.S. FIRE SAFETY VALVE</p> <p>L.C. LOCK CLOSED</p> <p>L.O. LOCK OPEN</p> <p>N.C. NORMALLY CLOSED</p> <p>N.O. NORMALLY OPEN</p> <p>P.P. PERSONAL PROTECTION</p> <p>S.C. SAMPLE CONNECTION</p> <p>ST STEAM TRACED</p> <p>ET ELECTRICAL TRACED</p> <p>CV CHECK VALVE</p> <p>HOV HAND OPERATED VALVE</p> <p>SK SKIPPER</p> <p>TK WASTE TANK</p> <p>V VENT</p> <p>D DRAIN</p> <p>DP DRAINFIT</p> <p>DDP DEEP DRAINFIT</p> <p>ADV AIR OPERATED VALVE</p> <p>MEDIUM/SERVICE</p> <p>NG NATURAL GAS</p> <p>BA BREATHING AIR</p> <p>IA INSTRUMENT AIR</p> <p>PA PLANT AIR</p> <p>FG FUEL GAS</p> <p>N NITROGEN</p> <p>VA VAPOR RETURN</p> <p>P PRODUCT</p> <p>PL PAILING</p> <p>PR PRODUCT RECOVERY</p> <p>A ADDITIVES</p> <p>FH FOAM</p> <p>C CONDENSATE</p> <p>S STEAM</p> <p>WW WASTE WATER</p> <p>CW COOLING WATER</p> <p>FW FIRE WATER</p> <p>HW HOT WATER</p> <p>DW DENWATER</p> <p>MW MUNICIPAL WATER</p> <p>ATM ATMOSPHERIC</p>																																																																																																																																																																																																									
<p>VALVES</p> <p>NOTE: ALL VALVES HAVE FLANGES</p> <p>230 GATE VALVE</p> <p>231 CHECK VALVE</p> <p>232 GLOBE VALVE</p> <p>233 BALL VALVE</p> <p>234 SEUT VALVE</p> <p>235 DIAPHRAGM VALVE</p> <p>236 NEEDLE VALVE</p> <p>237 BUTTERFLY VALVE</p> <p>238 PLUG VALVE</p> <p>239 ANGLE VALVE</p> <p>240 THREE WAY VALVE</p> <p>241 POUR WAY VALVE</p> <p>242 CONTROL VALVE</p> <p>243 CONTROL VALVE</p> <p>244 CONTROL VALVE WITH VALVE POSITIONER</p> <p>245 SOLENOID VALVE (ONE PORT CLOSED) (SV)</p> <p>246 3-WAY SOLENOID VALVE (ONE PORT CLOSED) (SV)</p> <p>247 CONTROL VALVE SELF CONTAINED</p> <p>248 CONTROL VALVE SELF CONTAINED</p> <p>249 MOTOR OPERATED VALVE</p> <p>250 BACK PRESSURE VALVE</p> <p>251 PRESS SAFETY VALVE/THERMAL RELIEF VALVE</p> <p>252 PRESSURE & VACUUM RELIEF VALVE</p> <p>253 EMERGENCY RELIEF VALVE</p> <p>261</p>	<p>236 FLANGE CONNECTION</p> <p>234 RUPTURE DISK</p> <p>235 SPECTACLE BLIND FLANGE (CLOSED) (SB)</p> <p>236 SPECTACLE BLIND FLANGE (OPEN) (SB)</p> <p>237 SPADE</p> <p>238 RESTRICTION ORIFICE</p> <p>239 ORIFICE FLANGE</p> <p>238 SPOOL PIECE</p> <p>239 CLAMPED CONNECTION</p> <p>239 CLAMPED CONNECTION (OPEN END)</p> <p>236 FLANGE</p>	<p>270 CENTRIFUGAL PUMP</p>	<p>270 CENTRIFUGAL PUMP</p>	<p>270 CENTRIFUGAL PUMP</p>																																																																																																																																																																																																										
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Measurement and Control

Obligation of a mechanical engineer

- is to understand the markings on the technological diagram.
- to know the conditions under which individual measuring devices will work. After consultation with other specialists, specify the max. operating parameters, boundary conditions or possible dangerous conditions
- emphatically ask for the correct design of the measuring element in case there is an aggressive substance in the system, or particles that can cause mechanical damage
- Cooperate in choosing a suitable connection (Flange, thread... Etc.)
- Strictly follow the requirements of the manufacturer of the measuring equipment for the correct design of the pipeline. (e.g. a straight section of the 10D pipe when measuring the flow rate, the correct position of the heat sink, etc.)

Measurement and Control

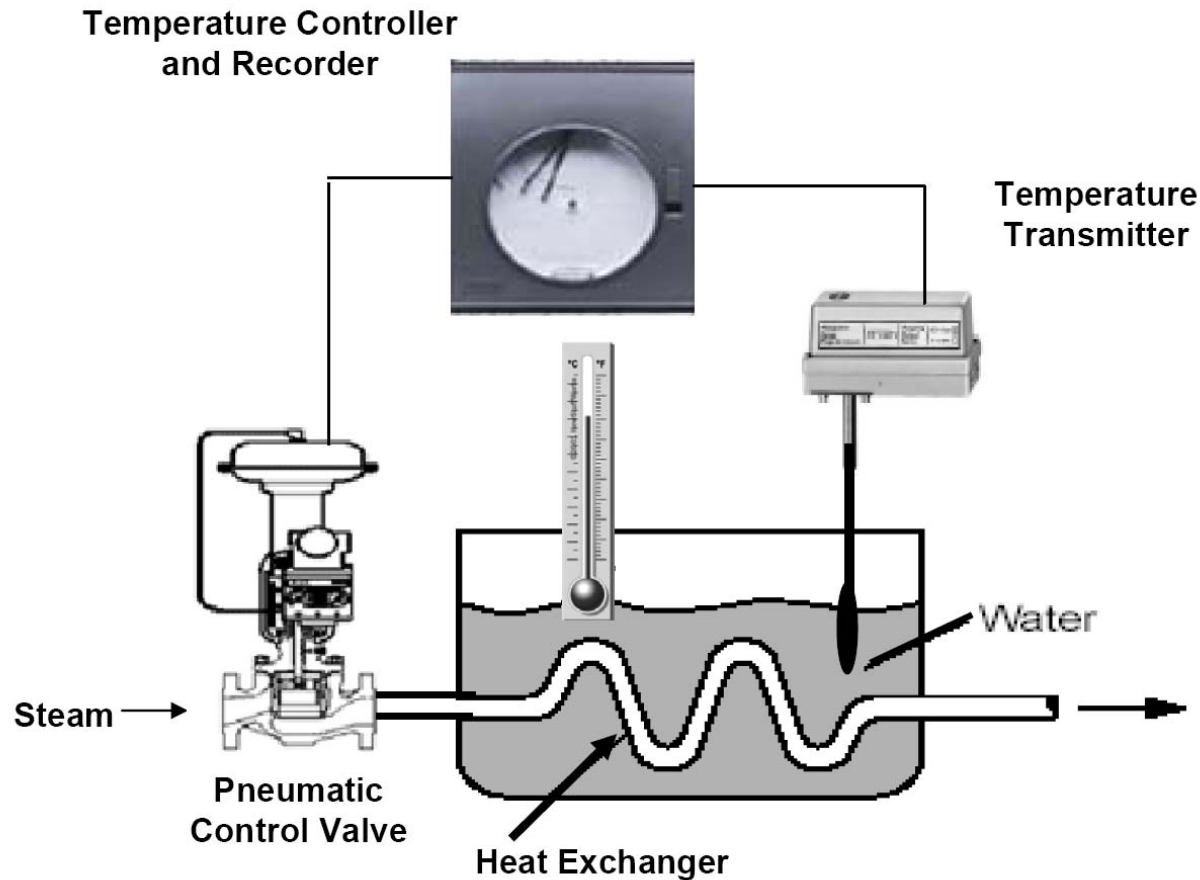


Control

It serves to maintain the required conditions in a certain system by adjusting (controlling) selected variables.

Measurement
Control
Regulation

Measurement and Control



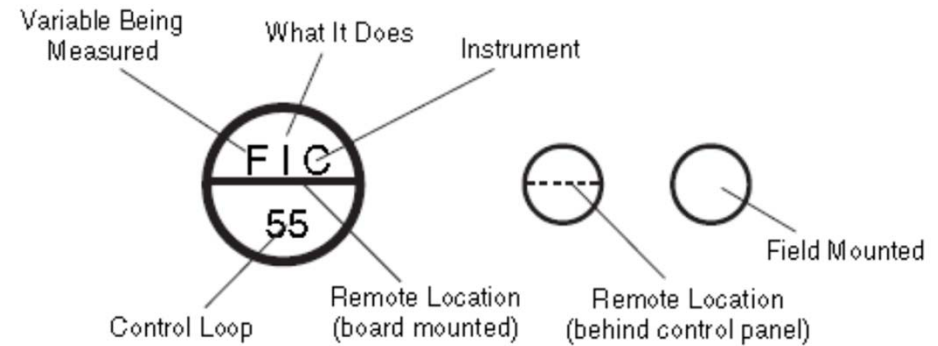
Control loop /
Measuring circuit /

Symbolically represent
the measuring circuit
in the form of symbols
and markings.

What must it contain?

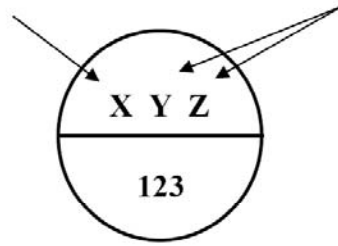
What we need to
understand, what we
don't ..

Measurement and Control



The first letter is used to designate the **measured variable**

The succeeding letter(s) are used to designate the **function** of the component, or to **modify** the meaning of the first letter.



Pressure

Level

Flow

Temperature

Indicator

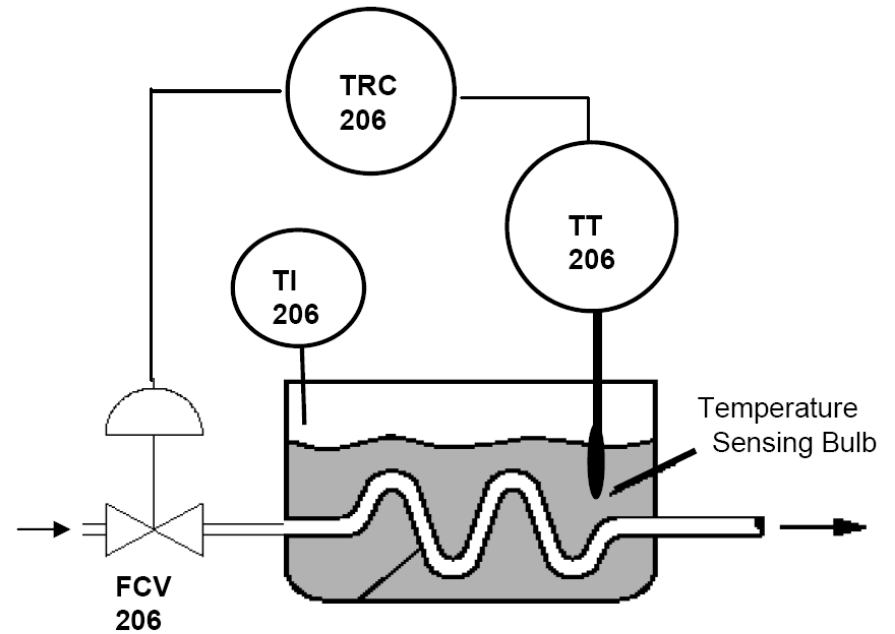
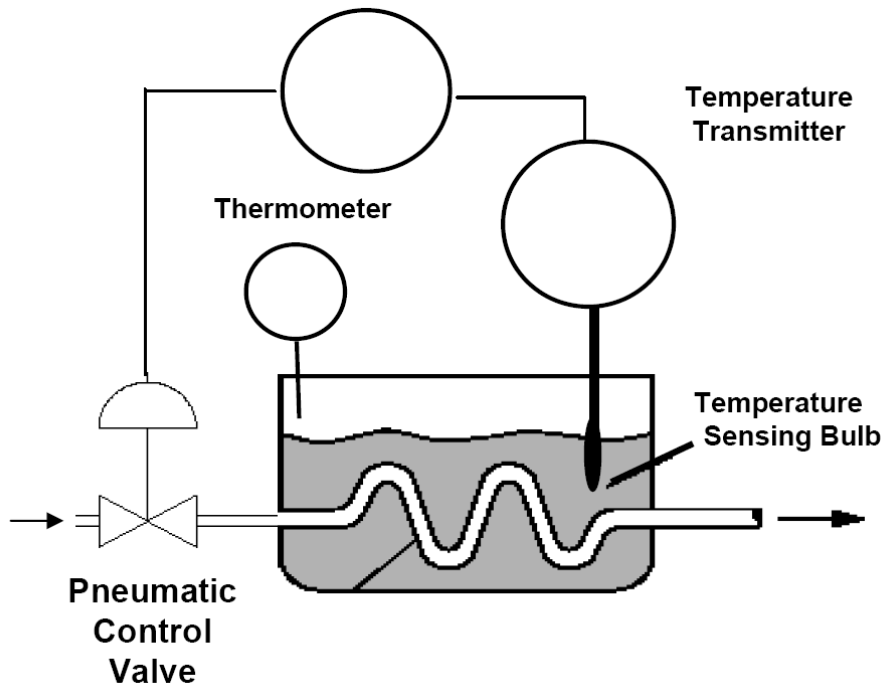
Recorder

Controller

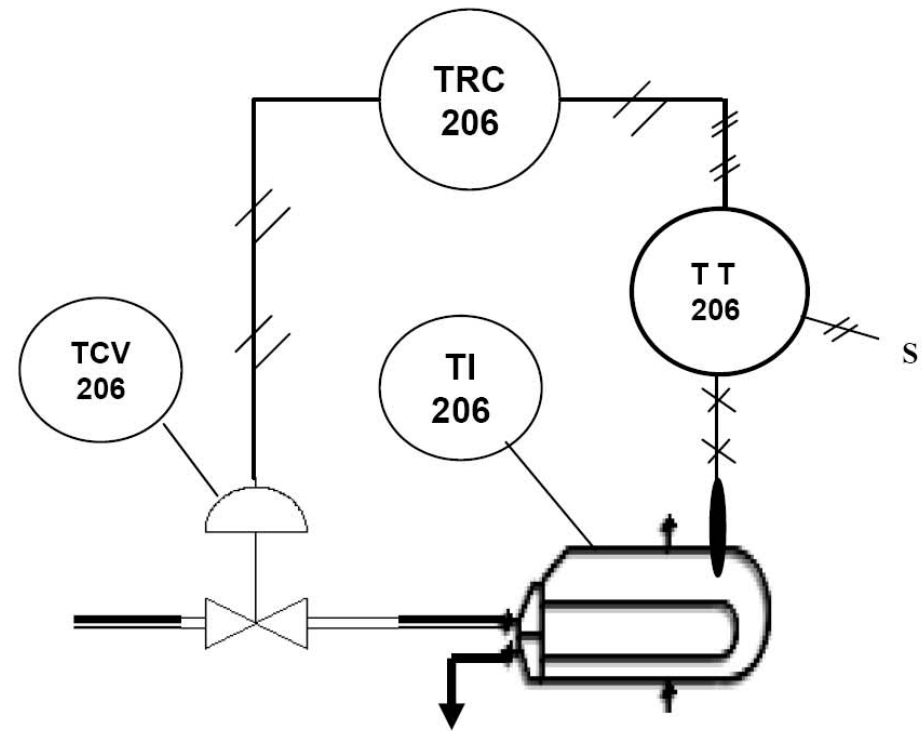
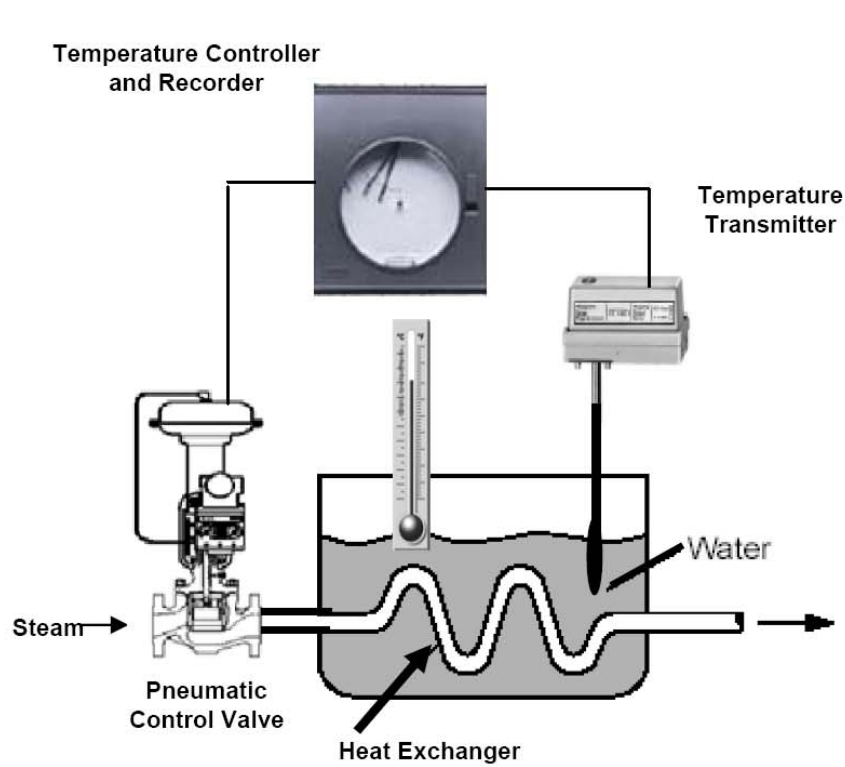
Transmitter

Measurement and Control

Temperature Controller and Recorder

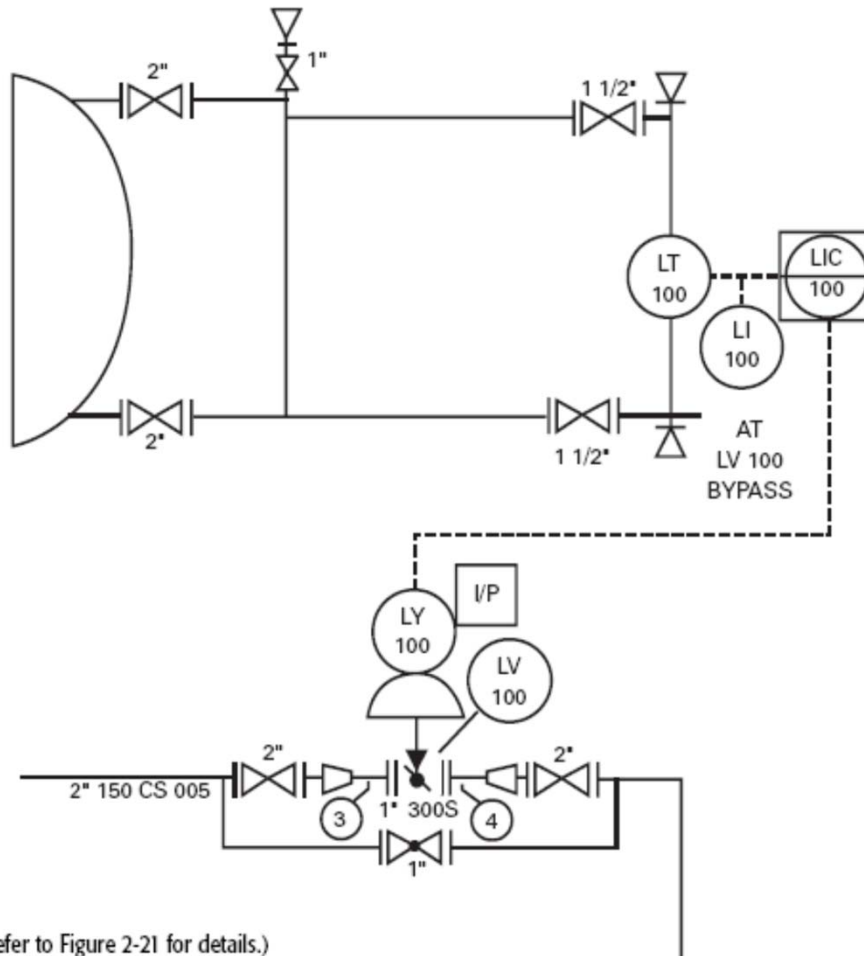


Measurement and Control



Measurement and Control

Examples of control loop: Level /L/



(Refer to Figure 2-21 for details.)

Measurement and Control

level sensors /L/

