

Instrumentasi Industri

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Referensi Kuliah

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2. K. Astrom and T. Hagglund, **PID Controllers: Theory, Design and Tuning**, ISA, 1995
3. William L. Luyben and Michael L. Luyben, **Essentials of Process Control**, McGraw-Hill, 1997
4. Shankar Narashimhan and Cornelius Jordache, **Data Reconciliation & Gross Error Detection: An Intelligent Use of Process Data**, Gulf Publishing Co., 2000

BAB I

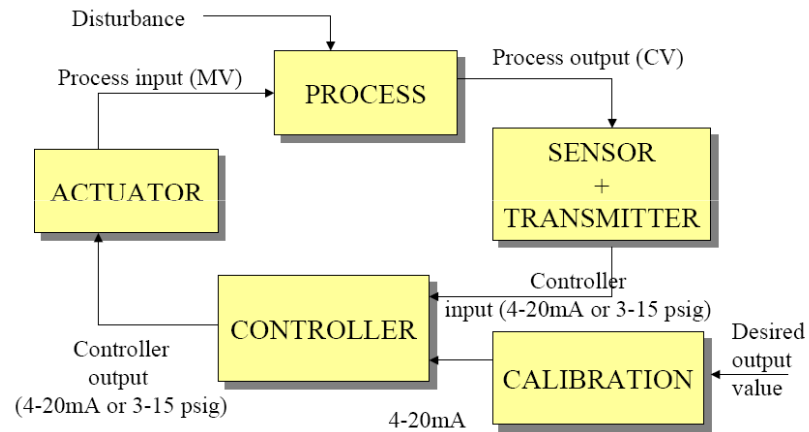
Pengenalan Teknologi Instrumentasi & Diagram Instrumen

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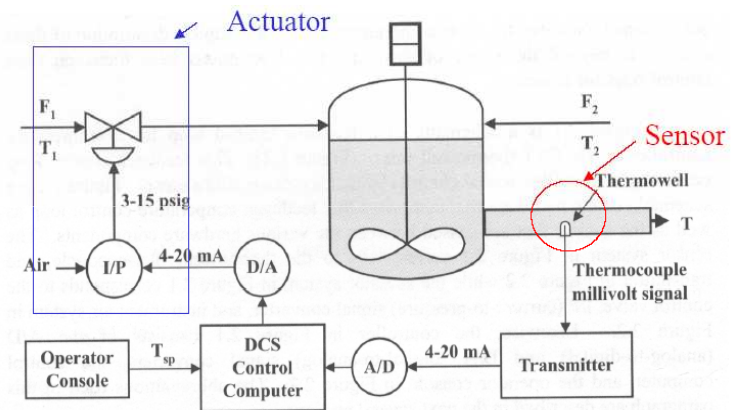
Components of Process Control Instrumentation

- ◆ Sensors (orifice, thermocouple, dP cell)
- ◆ Transmitters (signal converter, amplifier, conditioner)
- ◆ Transmission line (electronic/electrical, air tube/pneumatic, data line)
- ◆ Controllers (Computer, PLC, DCS)
- ◆ Actuators (Control Valve)

Typical Configuration



Example of Control Loop



Standard Instrumentation Signal Level

- ◆ Before 1960, instrumentation in the process industries utilized pneumatic (air pressure) signals to transmit measurement and control information almost exclusively.
- ◆ These devices make use of mechanical force-balance elements to generate signals in the range of 3 to 15 psig, an industry standard.
- ◆ Since about 1960, electronic instrumentation has come into widespread use.

Process Transmitter

- ◆ A transmitter usually converts the sensor output to a signal level appropriate for input to a controller, such as 4 to 20 mA.
- ◆ Transmitters are generally designed to be *direct acting*.
- ◆ In addition, most commercial transmitters have an adjustable input range (or span).
- ◆ For example, a temperature transmitter might be adjusted so that the input range of a platinum resistance element (the sensor) is 50 to 150 °C.

Process Transmitter

◆ In this case, the following correspondence is obtained:

| Input | Output |
|--------|--------|
| 50 °C | 4 mA |
| 150 °C | 20 mA |

◆ This instrument (transducer) has a lower limit or *zero* of 50 °C and a range or *span* of 100 °C.

Process Transmitter

◆ For the temperature transmitter discussed above, the relation between transducer output and input is

$$T_m (\text{mA}) = \left(\frac{20 \text{ mA} - 4 \text{ mA}}{150 ^\circ\text{C} - 50 ^\circ\text{C}} \right) (T - 50 ^\circ\text{C}) + 4 \text{ mA}$$

$$= \left(0.16 \frac{\text{mA}}{^\circ\text{C}} \right) T (^\circ\text{C}) - 4 \text{ mA}$$

Implementation Mode

- Pneumatic
 - Transmission: Pressure signals (3-15 psig)
 - Control Calculation: Mechanical device (e.g., tubes, bellows)
 - Only very basic calculation can be performed
 - **Safe** in general
- Electronic Analog
 - Transmission: Analog electric signal (4-20 mA)
 - Control Calculation: Analog circuit
 - More advanced calculation but still not very flexible
 - Susceptible to contamination
 - Cannot be used in safety-sensitive processes

Implementation Mode

- Digital
 - Transmission: either analog signal (which gets converted to digital signal just before entering the controller) or digital signal (sequence of 0-1 binary pulses)
 - A/D: converts analog signal to digital signal
 - D/A: converts digital signal to analog signal
 - Controller: digital computer (can be complex).
 - High flexibility and easy reconfiguration.
 - Easy access of remote data and past data.

Advantages of Digital Implementation

- Increased flexibility – much easier to manipulate data (on computers) than analog signals (through analog devices)
 - Signal conditioning (e.g., noise filtering)
 - Control calculation (“algorithm”)
- Easy storage and display
- More precision
 - Little signal degradation
- Opportunity for improved control
 - Smart actuators and sensors
 - More sophisticated control algorithms
 - Easily reconfigurable

Sensor Terminology

- ◆ **Span**
- ◆ **Zero**
- ◆ **Accuracy**
- ◆ **Repeatability**
- ◆ **Process measurement dynamics**
- ◆ **Calibration**

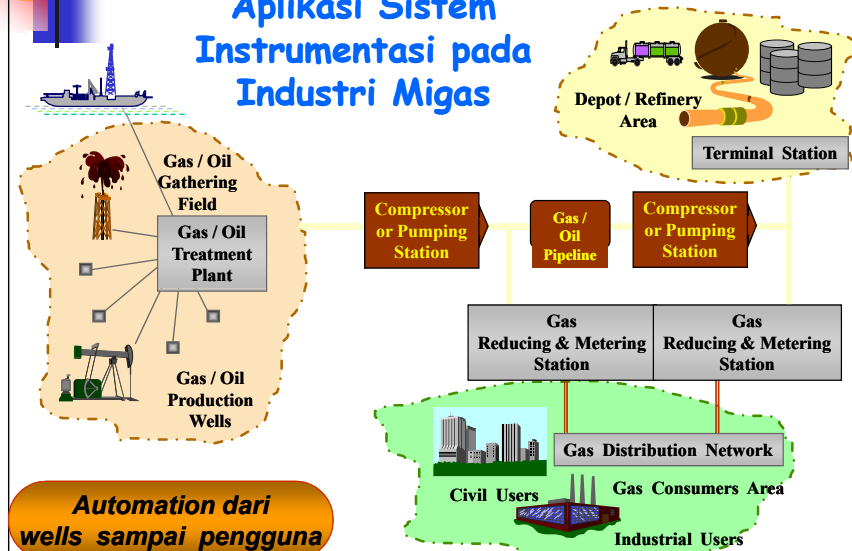
Span and Zero Example

- ◆ Consider a case in which the maximum temperature that is to be measured is 350°F and the minimum temperature is 100°F.
- ◆ Then the zero is 100°F and the span is 250°F
- ◆ In addition, if the measured temperature is known at two different sensor output levels (i.e., ma's), the span and zero can be calculated directly.

Smart Sensor

- ◆ Sensors with onboard microprocessors that offer a number of diagnostic capabilities.
- ◆ Smart pH sensors determine when it is necessary to trigger a wash cycle due to buildup on the electrode surface.
- ◆ Smart flow meters use statistical techniques to check for plugging of the lines to the DP cell.
- ◆ Smart temperature sensors use redundant sensors to identify drift and estimate expected life before failure.

Aplikasi Sistem Instrumentasi pada Industri Migas



Automation dari wells sampai pengguna

Pendahuluan

1-17

Teknologi Instrumentasi Konvensional



Pendahuluan

1-18

Teknologi Otomasi Baru

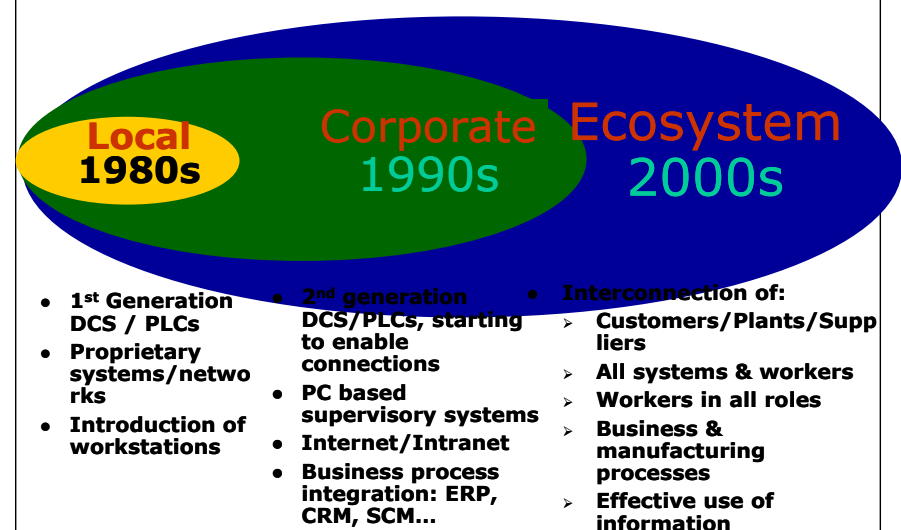


Rendering courtesy of The Foxboro Company

Pendahuluan

1-19

Evolusi Teknologi Otomasi

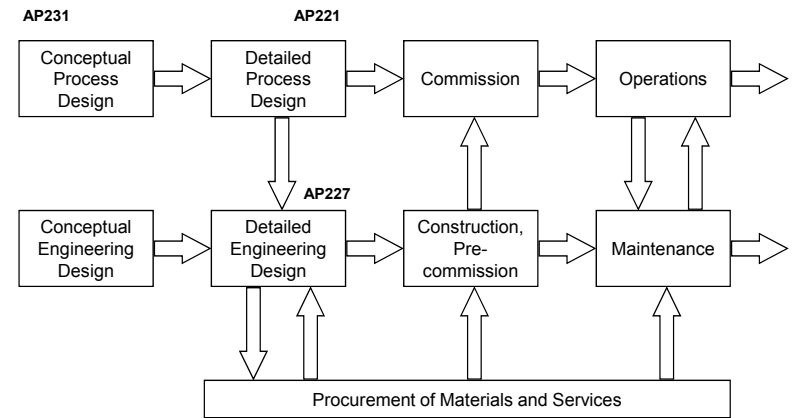


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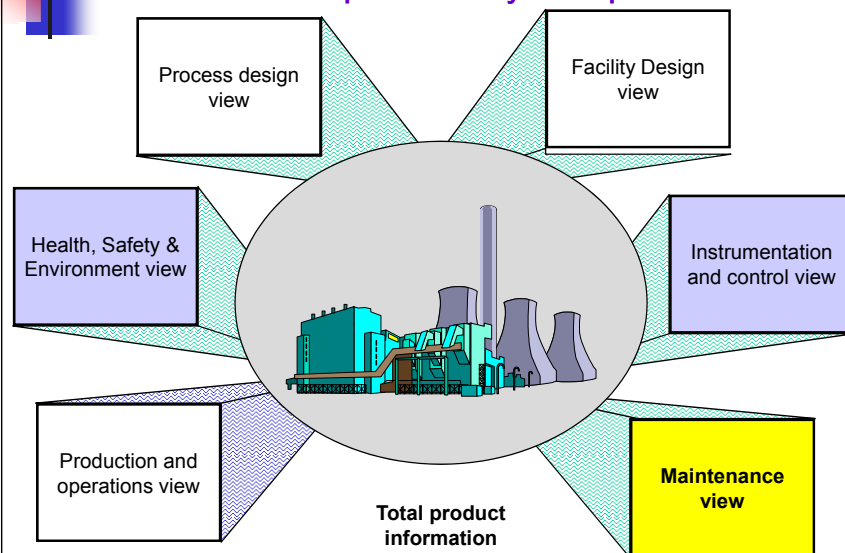
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Introduction to the Process Industry

STEP and the Plant Life-cycle



Discipline/life-cycle specific views



Facility & Equipment Specifications

Process & Instrumentation Diagram

- Identification of plant items
- Classification of plant items
- Composition and properties of plant items
- Connection of plant items
- Physical and functional viewpoints
- Shape representation (3D)

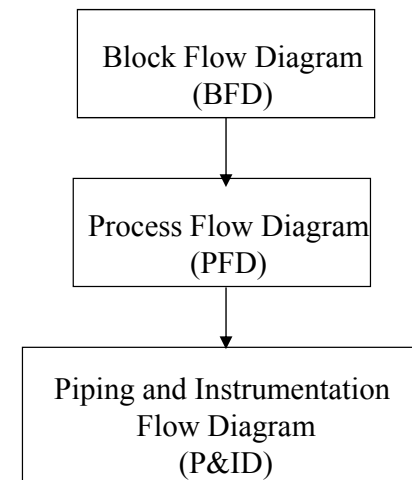
Process Flow Diagram

- Identification and description of equipment
- Identification of major instrumentation and valves
- Stream identification, description and properties
- Temperature, pressure and flow quantities
- Utility summaries

Operations & Maintenance

- ↓ Safety systems & procedures
- ↓ Operating manuals & procedures
- ↓ Troubleshooting guides
- ↓ Pilot plants
- ↓ Field tests
- ↓ Analysis results
- ↓ Sample results
- ↓ Process control
 - Control loops
 - Process measurements
- ↓ Log sheets, reading sheets, checksheets
- ↓ Operating modes

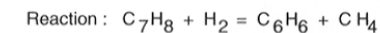
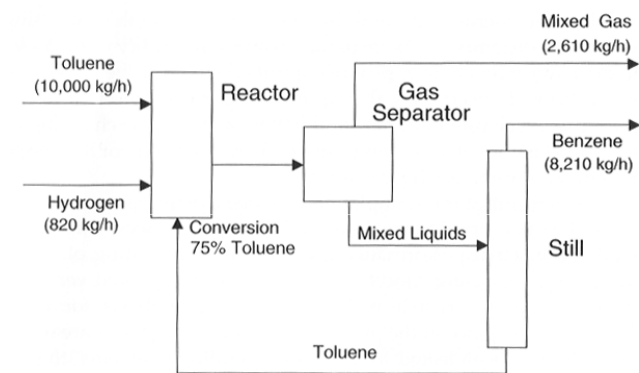
Chemical Process Diagrams



Block Flow Diagrams

- Give a clear overview of a process, uncluttered by details.
- Each block represents a process function, which in reality may consist of several pieces of equipment.
- Useful for conceptualizing new processes.
- Often used as a starting point for PFDs.
- Especially useful in oral presentations.

Block Flow Diagram



Block flow process diagram for the production of benzene.

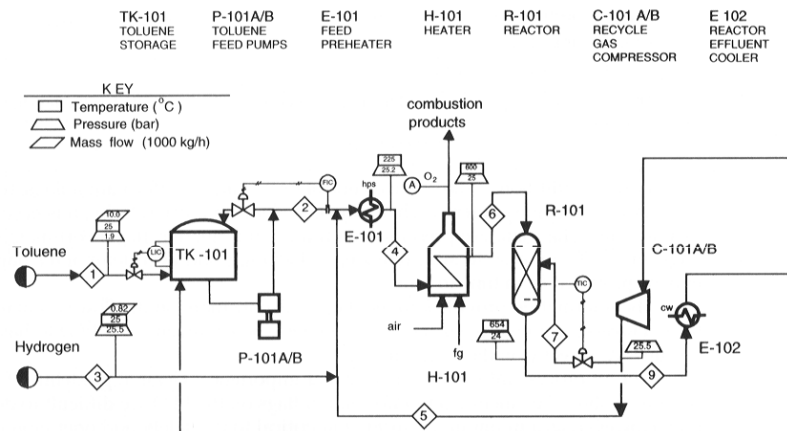
Convention and Format for Block Flow Diagrams

- Operations shown by blocks.
- Major flow lines shown with arrows giving direction of flow.
- Flow goes from left to right whenever possible.
- Light stream (gases) toward top with heavy stream (liquids and solids) toward bottom.
- Critical information unique to process supplied.
- If lines cross, then the horizontal line is continuous and the vertical line is broken (true for all chemical process diagrams).
- Simplified material balance provided.

Process Flow Diagrams

- Much more complex than a BFD.
- Will include the following information.
 - Major equipment with names, numbers and descriptions
 - All streams shown with number, process conditions, and chemical composition. The latter two may be shown directly on the PFD or on an accompanying stream table.
 - All utility streams to major equipment
 - Basic control strategies and control loops for normal operation.

Process Flow Diagram



Benzene process flow diagram (PFD) for the production of benzene via the hydrodealkylation of toluene.

Piping and Instrumentation Diagrams (P&ID's)

- P & ID's represent the last step in process design
- Requires completed process flow diagrams (PFD's)
- P & ID's are a key document for construction and operation of a facility
 - The source of data for instrument lists, equipment lists, piping isometrics.
 - Referred to frequently during HAZOP, startup, routine operation, maintenance, debottlenecking, and upgrades
- A process cannot be adequately designed without proper P & ID's

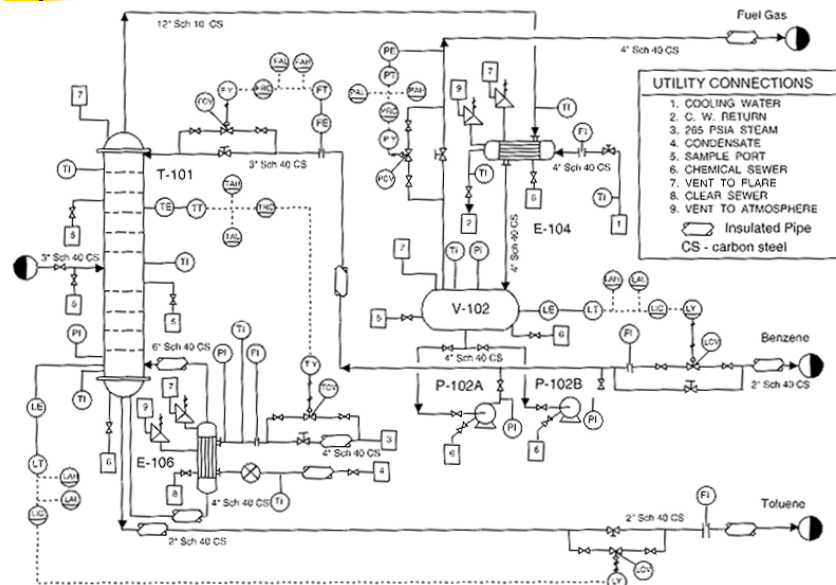


Figure 1.7 Preliminary piping and instrumentation diagram for benzene distillation. (Adapted from Kaufman, D., *Flow Sheets and Diagrams*, AIChE Modular Instruction, Series G: Design of Equipment, series editor J. Beckman, AIChE, New York, 1986, vol I, Chapter G.1.5, AIChE copyright, © 1986 AIChE, all rights reserved)

Importance of P&IDs

- The P&ID is the last stage of process design and serves as a guide by those who will be responsible for the final design and construction. Based on the P&ID:
 - Mechanical and civil engineers will design and install pieces of equipment.
 - Instrument engineers will specify, install, and check control systems
 - Piping engineers will develop plant layout and elevation drawings.
 - Project engineers will develop plant and construction schedules.

Generation of Drawings and Illustrations

- Up to the 1960s, all engineering curricula emphasized engineering graphics.
 - Tedious, labor-intensive manual process.
 - Chemical engineering programs typically dropped the requirement in the 1970s.
- CAD (computer-aided design) software became widespread in the 1980s.
 - Very powerful and flexible, but had a very steep learning curve.
- Engineers usually have draftspeople generate their drawings.
 - Industry standard for professional draftspeople is AutoCAD.
 - Installed in our computer lab.

Generation of Drawings by Engineers

- However, we must communicate with draftspeople, and sometimes we must generate the drawings ourselves.
- Fortunately, new, easily learned software allows engineers to generate high quality drawings without investing large chunks of one's career in learning the tools.
 - Microsoft Visio Professional is a good example.
 - Visio has many standard templates, including good process engineering templates.
 - Standard MS Office interface.
 - Installed in our computer lab.
 - Available for purchase at HiTech for \$149.

Trend Perkembangan Instrument

- ❖ **Dari Elektromekanik ke Elektronik**
- ❖ **Smart Transmitters**
- ❖ **Komunikasi Digital**
- ❖ **Soft Calibration**
- ❖ **Field Device Block Functions**

Protokol Komunikasi dari Field Device

- Modbus
- DF-1
- Data Highway (DH)
- ControlNet
- DNP
- Hostlink
- ROC
- MMS
- Ethernet TCP/IP
- Fieldbus
- OPC (Hardware specific)
- Etc.