Energy Audit Methods Of Compressor

KOREA ENERGY AGENCY
17 JAN 2018

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Energy Audit Methods Of Compressor

Main Contents

1. Compressor Utility
2. Air Dryer Utility
3. Measuring Power Consumption

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1. COMPRESSOR UTILITY

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1. Compressor utility

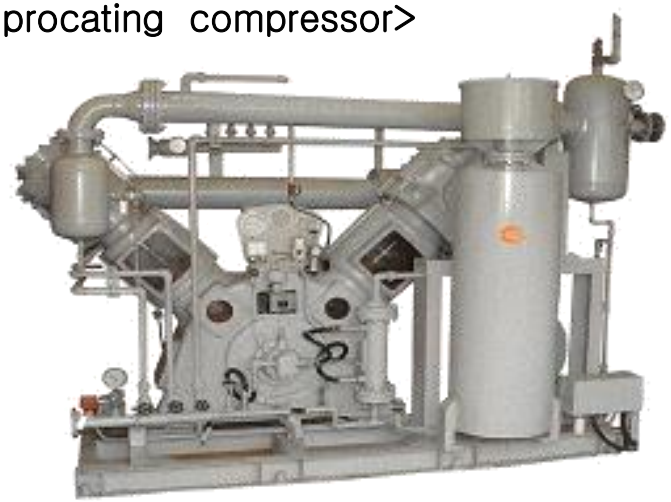
A. Compressor overview

♦ Compressor?

Machine which is compressed air to increase the pressure and speed. Blower which has pressure approximately less than 1.0 (kg/cm2) and compressor which has pressure approximately more than 1.0 (kg/cm2)

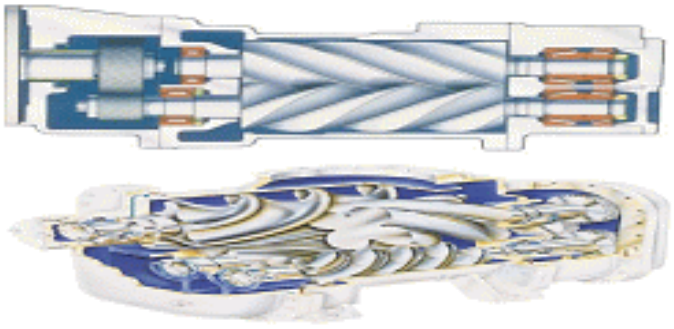
♦ Types of compressors

< Reciprocating compressor>



- Compression principle: the compression of the piston within the cylinder

< Screw compressor >



-Compression principle : when the turbine rotated in the sealed casing ,the air compressed through the volume is reduced

<Turbo compressor >

- Compression principle: After increase the speed of the air, through a diffuser to convert from pressure energy to velocity energy by high speed rotating impeller

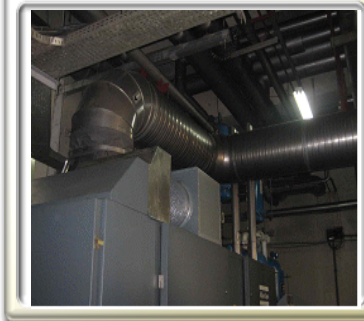
B. Procedure of compressor energy audit

1. Identifying System

2. Measuring Flow

3. Measuring Pressure

4. Checking Duct



5. Measuring Temperature

6. Measuring Air flow

7. Measuring Leakage

8. Measuring Elec. Power

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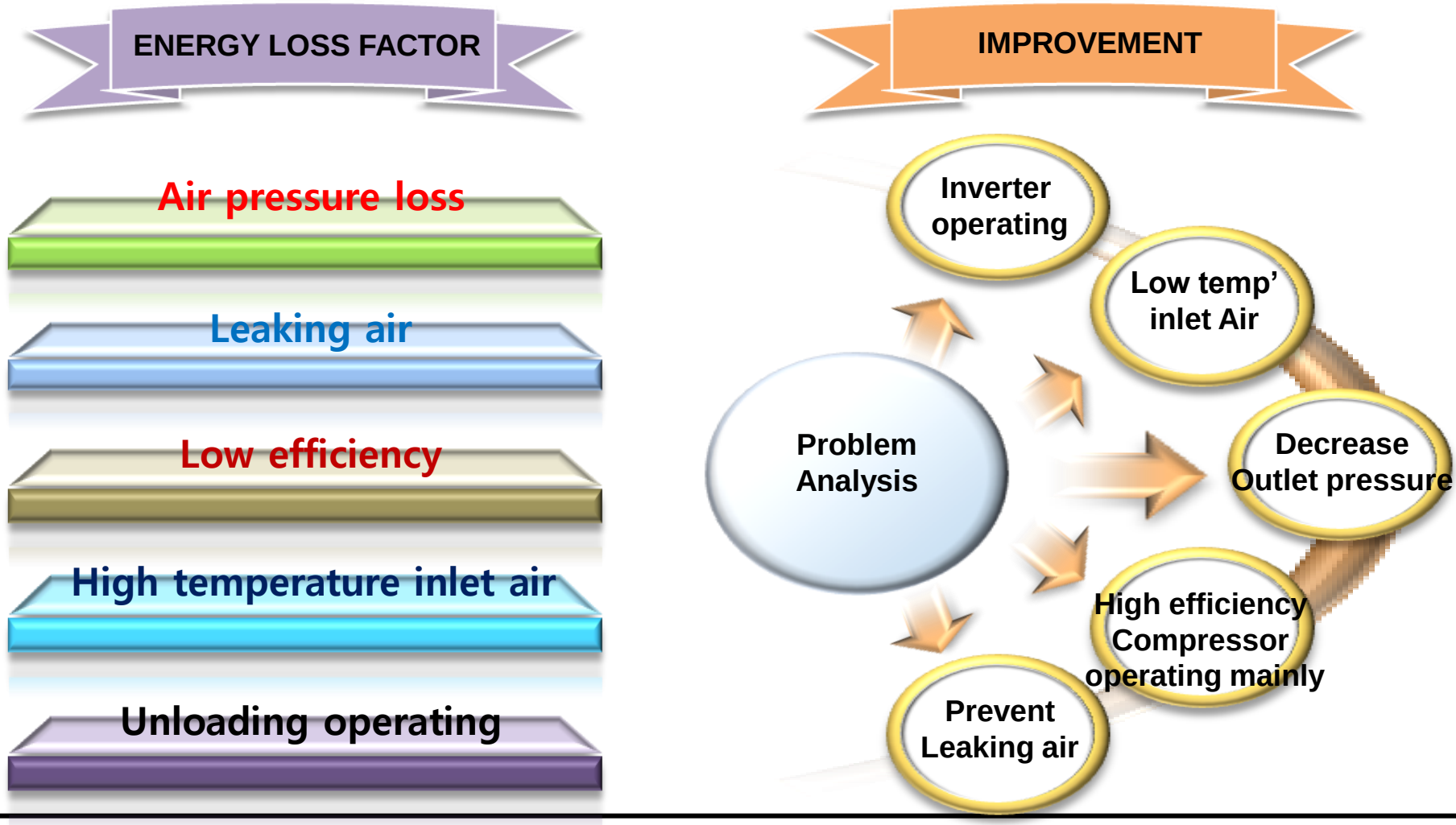
C. Energy loss factors and Improvement plan



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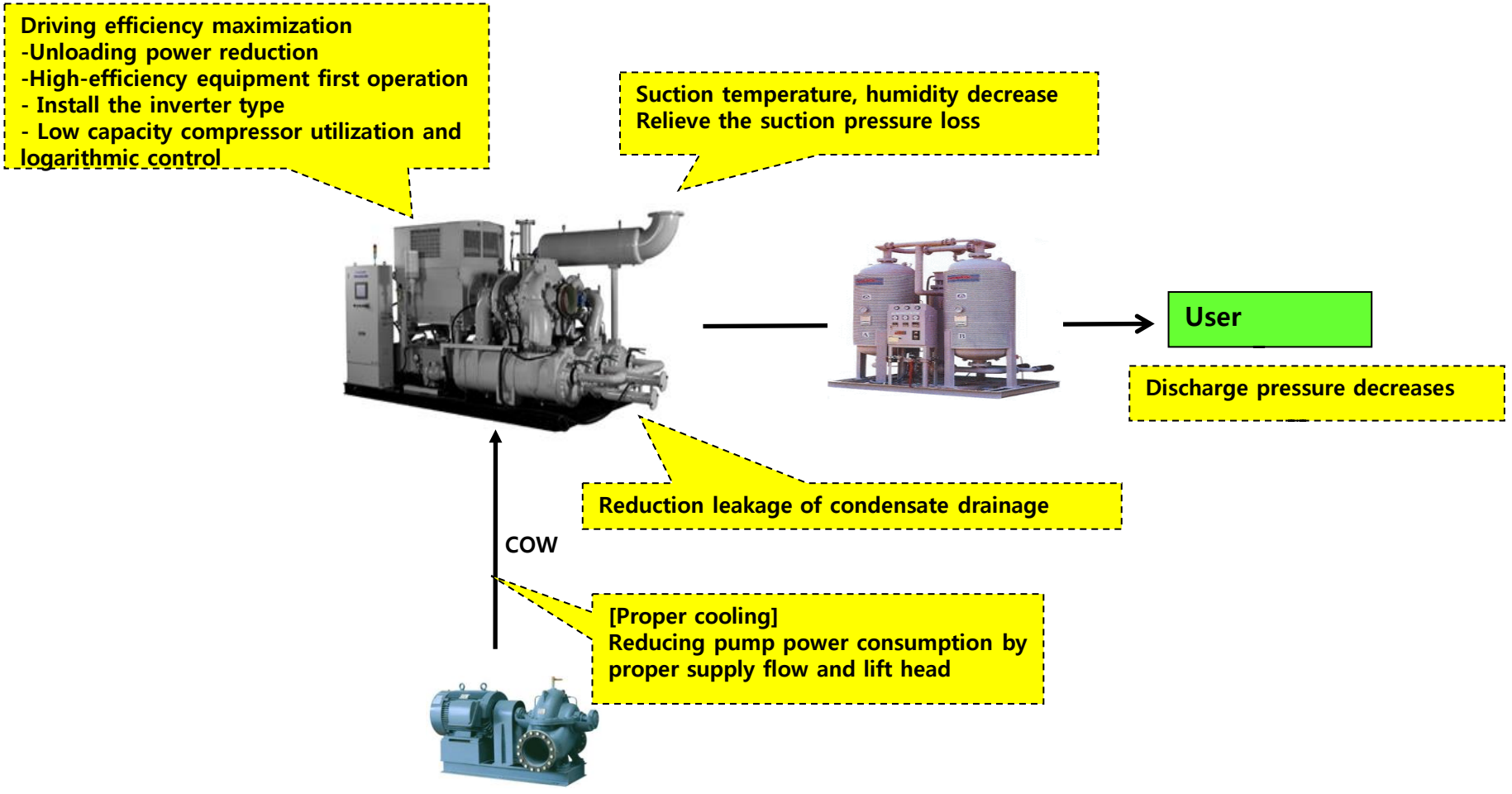
< Loss factor Schematic>



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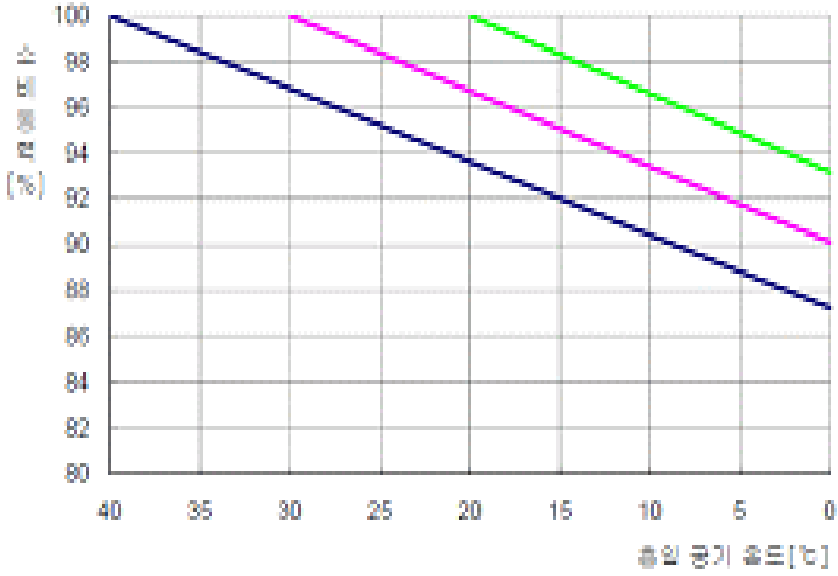
<Relationship between air compressor inlet temperature and power consumption >



When the intake temperature decreases 10 ℃, power savings is about 3%

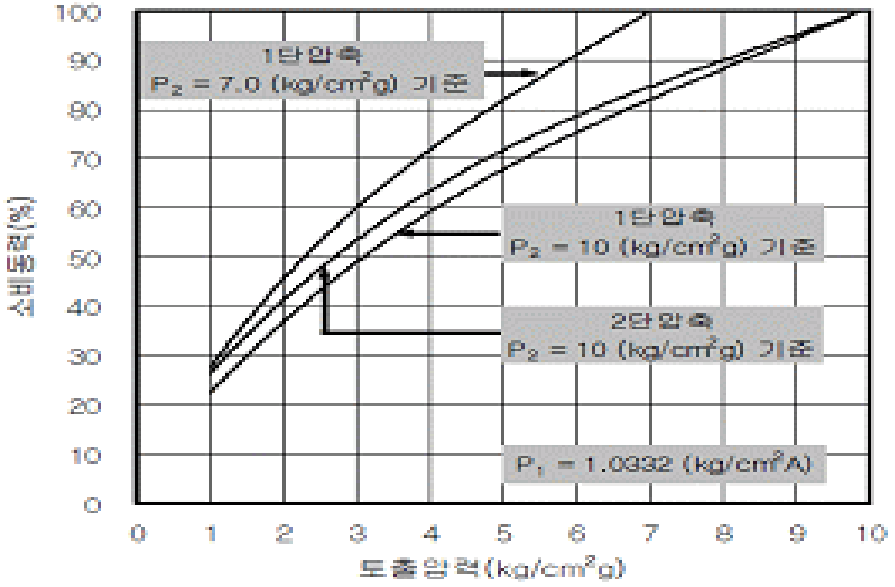
$$\varepsilon = \left(1 - \frac{T_2}{T_1}\right) \times 100$$

여기서 ε : 절전율[%]

T_1 : 개선전 흡입공기 절대온도[°K]

T_2 : 개선후 흡입공기 절대온도[°K]

<Relationship between air compressor outlet pressure and power consumption >



When the discharge pressure decreases 1㎏/㎠, power savings is about 8%

$$Lad \propto \left\{\left(\frac{P_2}{P_1}\right)^{\frac{(k-1)}{(a+1)k}} - 1\right\}$$

$$\varepsilon = \frac{Lad_1 - Lad_2}{Lad_1} \times 100$$

여기서 Lad : 이론단열 공기동력[kW]

P_1 : 대기압력(흡입압력)

P_2 : 개선 전후의 토출절대압력

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Case1. Improvement compression efficiency by suction outside air

A. Operation Status

- Increase power compression because of inside high temperature air compare with outside air

- Indoor air temperature rise, because boiler room and air compressor room are in same area.

  – Relationship between air compressor inlet temperature and power consumption

Charles' law

When temperature increase 1 ℃, The volume increase 1/273 in the same pressure

$V_1 / T_1 = V_2 / T_2$

– Note: When the compressor inlet temperature increase, equation of weight-loss of compressed air, weight-loss

Temperature difference 10 ℃ between outside(15℃) and suction air(25℃)

= [1 – (out side air temperature/ suction air temperature)] X 100

= [1 – (15℃ + 273 ℃) / (25 ℃ + 273 ℃)] X 100

= 3.4%

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- Problem Summary

Air temperature difference: 8 ° C

suction air temperature rise, because boiler room and air compressor room are in same area.

→ Low compressor operating efficiency → Increase of compressor power consumption

[Air compressor]

B. Improvement perspective and plan

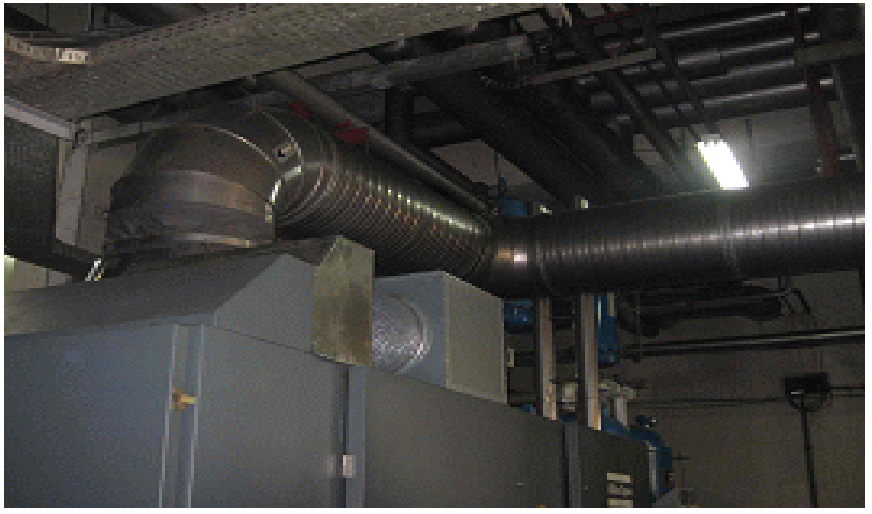
1) Improvement perspective

Decreasing suction temperature by using outside air → Increasing compressor efficiency → Reducing compressor power consumption

Installing outside air intake duct

2) Improvement plan

- Installing outside air section duct
  for 3 suction part for turbo compressor

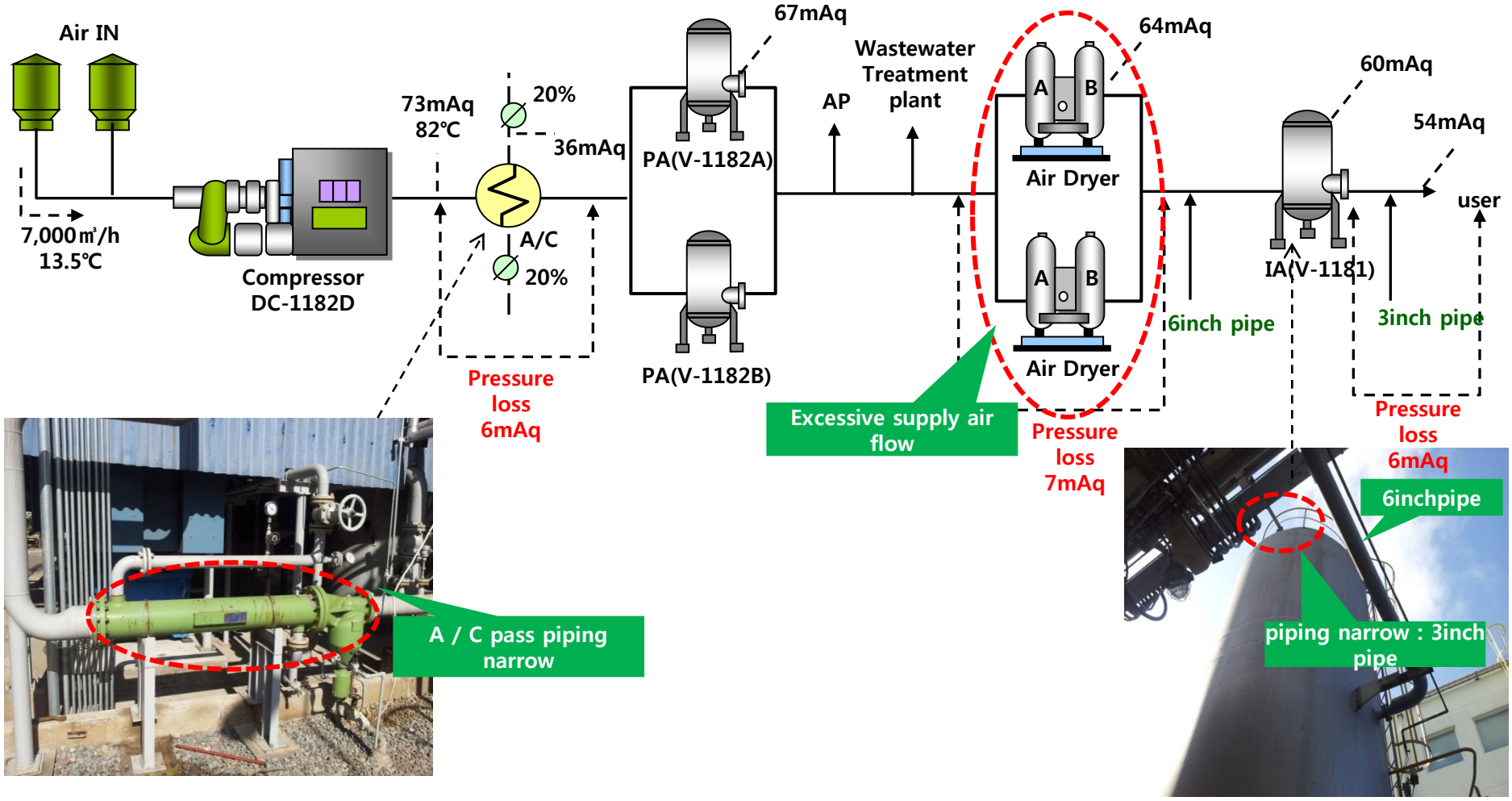


[Installing outside air intake duct]

Case2. Reduction compressor discharge pressure by reducing loss of pressure in compressed air system

A. Operation Status

●Driving Schematic



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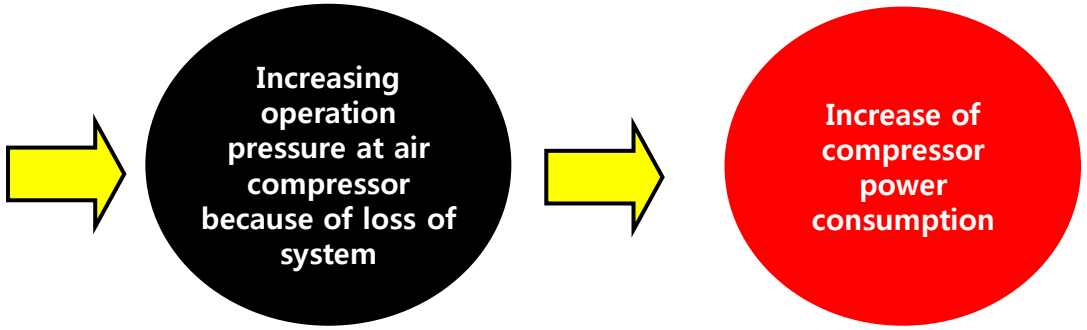
- Problem Summary

Pressure loss because of after cooler pass piping narrow

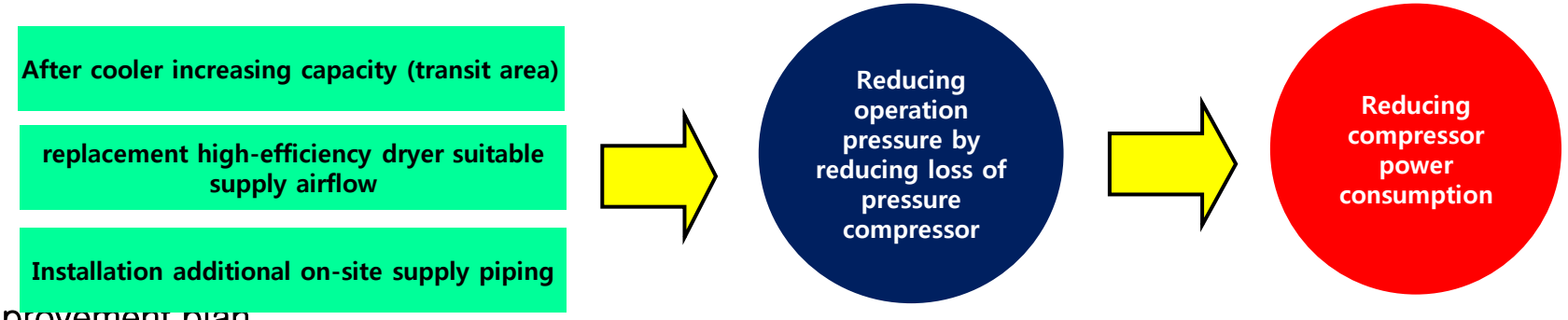
Pressure loss because of excessive Air dryer air flow

Piping loss because of piping pass size narrow from IA receive tank to field



B. Improvement perspective and plan

1) Improvement perspective



2) Improvement plan

- Minimizing unnecessary pressure loss in Air compressor system
  - Increasing the after cooler capacity of air compressor system(the area Compressed air to pass through)
  - Pressure loss reduction by decreasing Air flow rate to ½ through efficiency operating
  - Installation additional from IA Receiver Tank to on-site supply piping

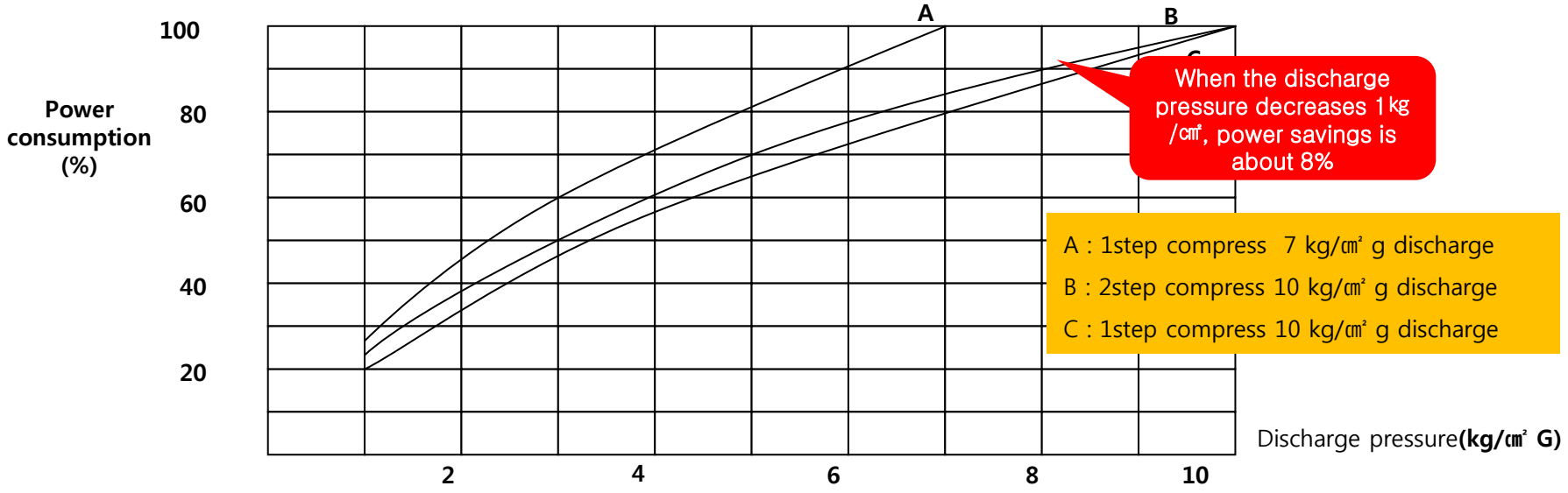
- When air flow rate is reduced to 1/2, expected pressure loss is reduced to1/4 (though improve pressure loss and increase the size of the piping)

● Equation of the air compressor discharge pressure reduction

$$L = \frac{(a+1)k}{k-1} \cdot \frac{P_s Q_s}{6120} \left[\left(\frac{P_d}{P_s} \right)^{\frac{(k-1)}{(a+1)k}} - 1 \right]$$

$$\varepsilon = \frac{L_{ad1} - L_{ad2}}{L_{ad1}} \times 100$$

● Relationship between air compressor outlet pressure and power consumption (Theory)



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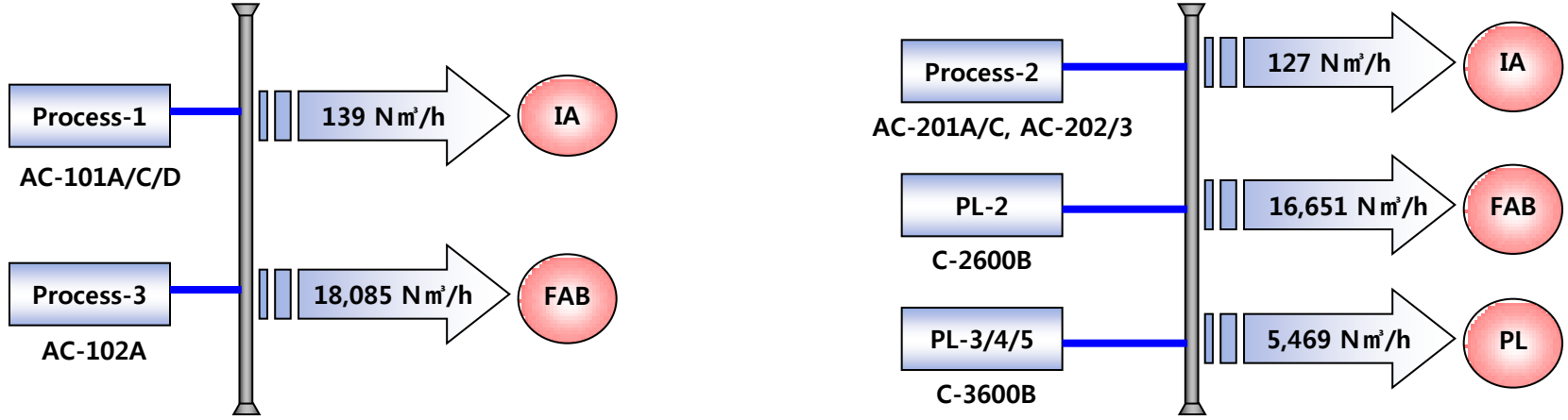
Case3. installing air compressor for low pressure(High / low pressure separation operation)

A. Operation Status

- Operation Status



- The 7 ~ 8.4kg/cm2 air made from the compressor room is supplied each field

- Approximately 50% of air compressed is used FAB and PL for removing moisture of Air Knife and separating product of packing, so regulator downstream pressure is within 1.0kg/cm2

B. Improvement plan

- Compressed air is made and supplied by each use area : Approximately 49.7% of low pressure can be used.

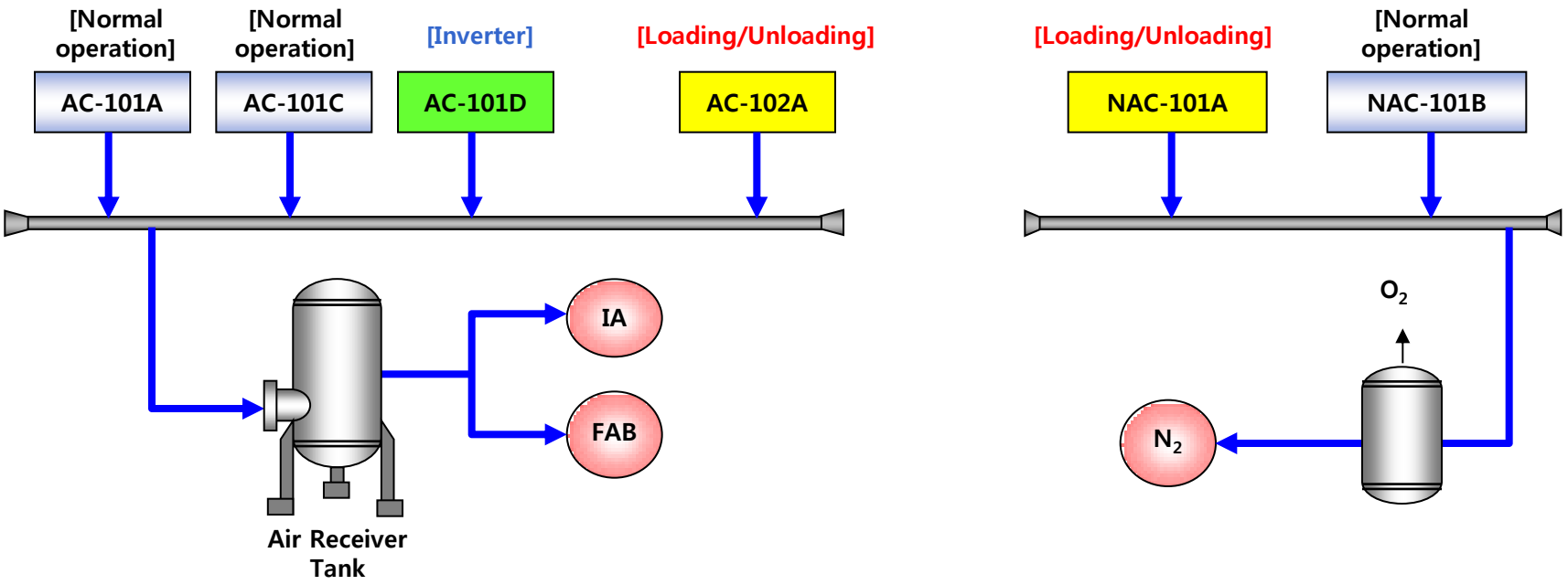
- Making and supplying air separately(high pressure (7 bar) and low pressure (3 bar)) : separating high / low pressure piping and installing low-pressure dedicated compressor

- Making more high air pressure, and secure safety by using Let · down during the lacking of low air pressure usage,

Case4. Savings unloading power by Integrated compressor operating

A. Operation Status

- Air compressor operation Status



- Separate operation of process (7.2 bar)and N2 production (9.0 bar)
- "AC-102A" for process and "NAC-101A" for N2 production are Loading/Unloading repeat operating by fluctuating load
- Each air compressor loading rate is 48.6(%)

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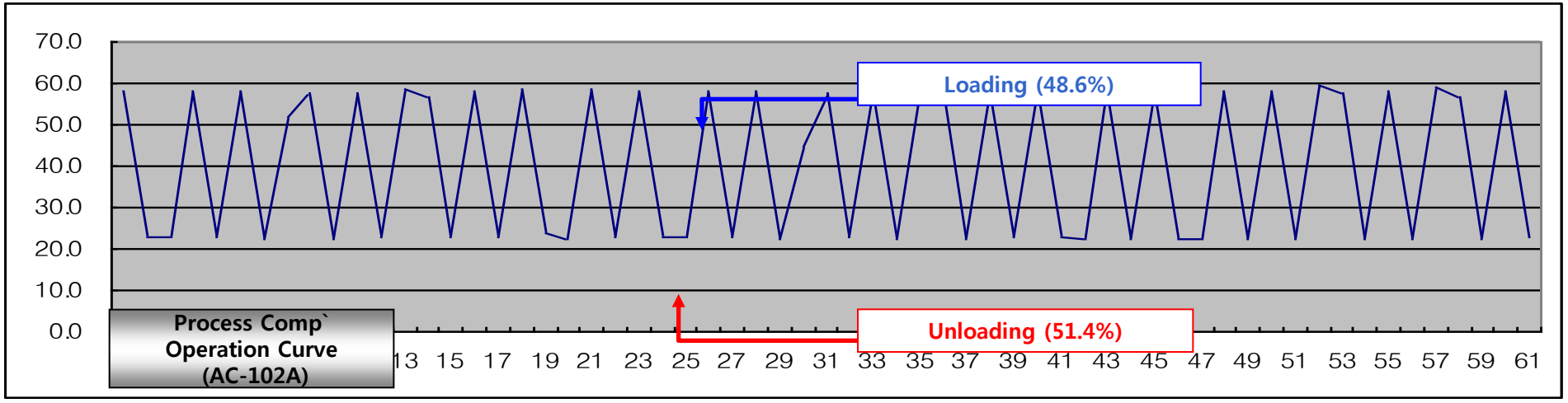
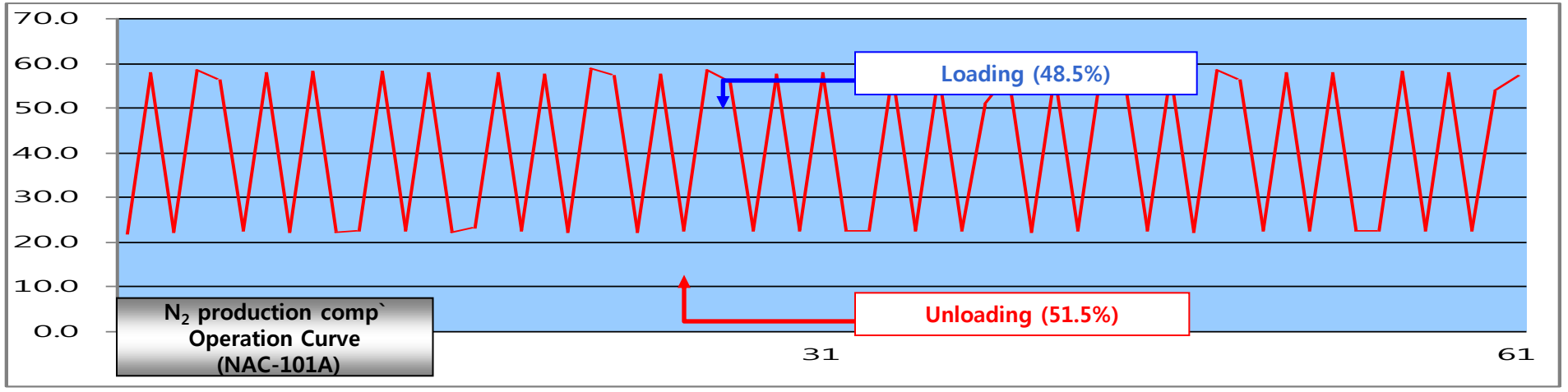
● Air compressor Loading Operation Status





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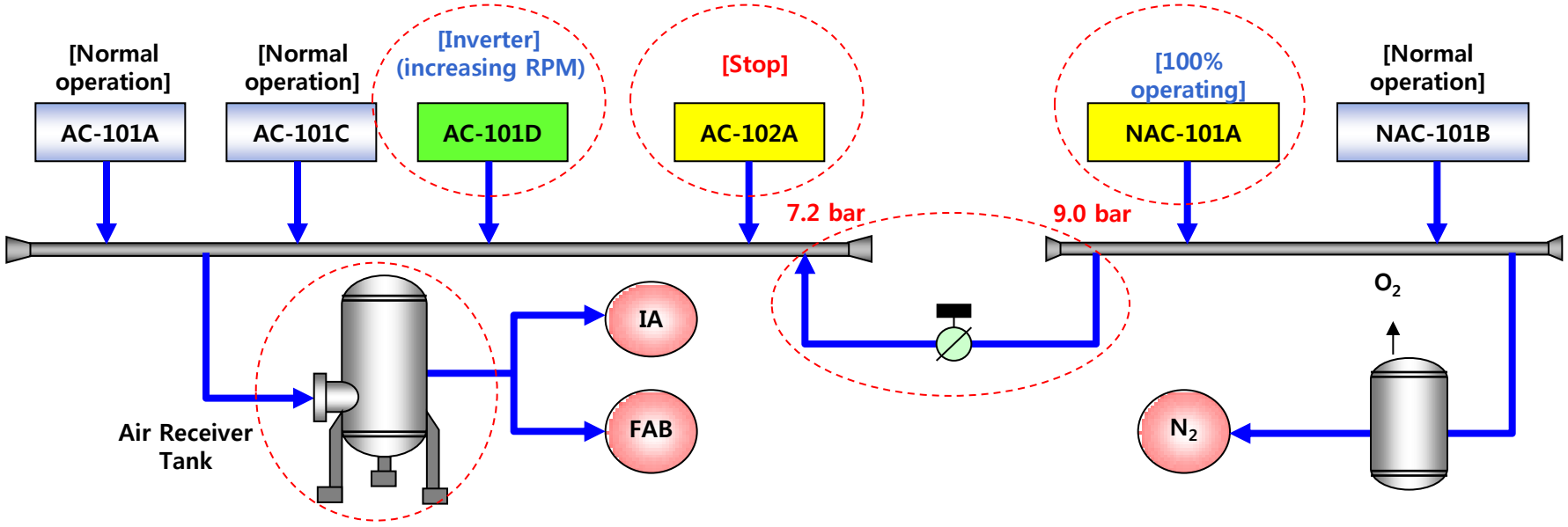
B. Improvement plan

- Integrated operation of N2 production and Process : supply Process (7.2bar) from N2 (9.0bar)
- N2 air compressor is used 100% , Process air compressor is stop to use
- Increasing RPM of Process inverter
  (inverter loading rate: 61.8% ⇒ 79.8%)



2. AIR DRYER UTILITY

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2. AIR DRYER Utility

A. AIR DRYER overview

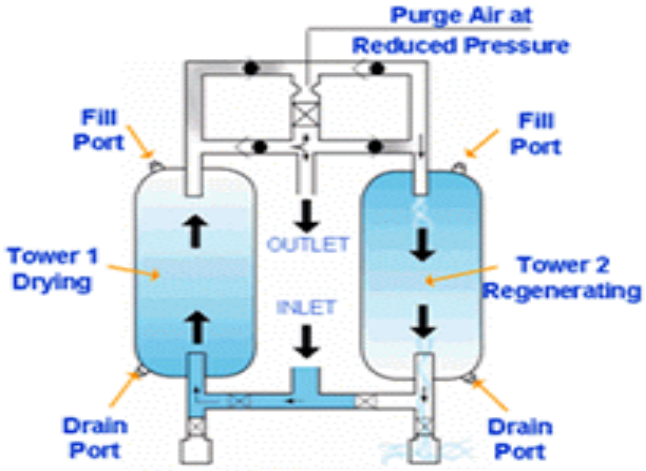
♦ AIR DRYER?

A machine which is installed in the compressed air line to remove the moisture and dust in the compressed air.

♦ Type of air dryer

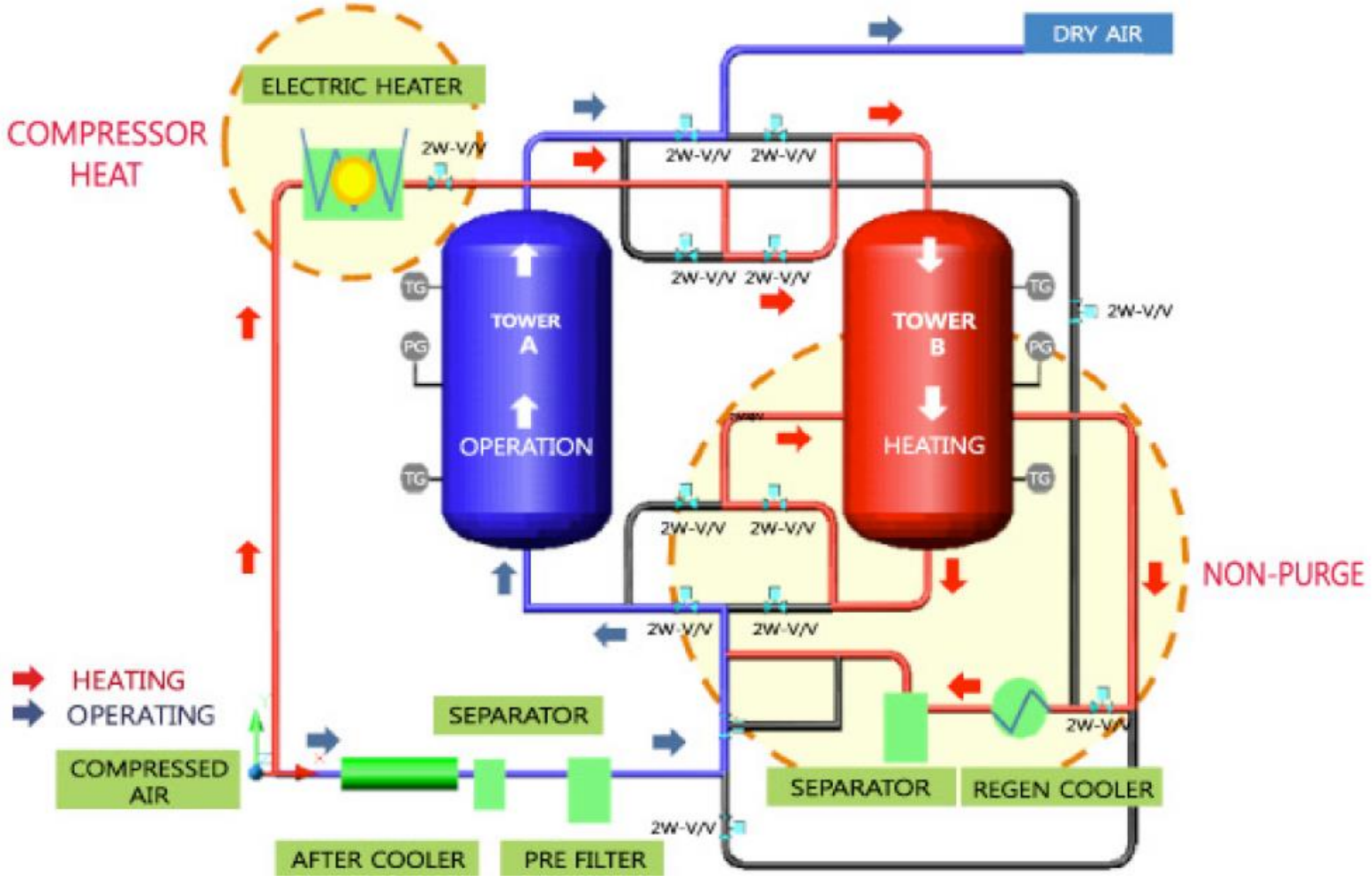
< Refrigeration Dryer>

<Desiccant Dryer>



< combination (Refrigeration + Desiccant) dryer>

<Non Purge Type dryer>



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B. Procedure of air dryer energy audit

Check Status

Check Operation Type

Measuring amount of Purge

Measuring Heater

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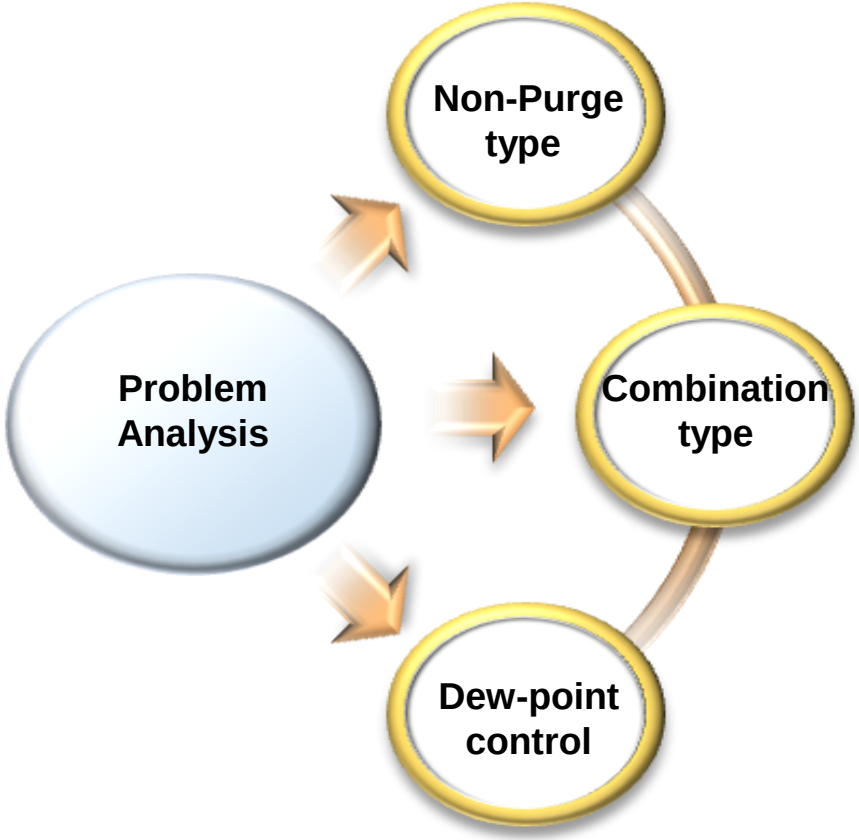
C. AIR DRYER energy loss factor and Improvement plan

ENERGY LOSS FACTOR

- Excessive purge air
- Excessive heater power
- Excessive heating/cooling time
- Degradation effect of dehumidification
- Air pressure loss

IMPROVEMENT



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< Loss factor Schematic >

Saving by improvement system
- Time Control -> dew point control
- Control excessive heating and cooling

Saving by Mechanical
(Purge flow reduction)
-Blower type
-Non-purge type

Saving by Mechanical
(Heater power reduction)
-combination dryer type
-Non-purge type

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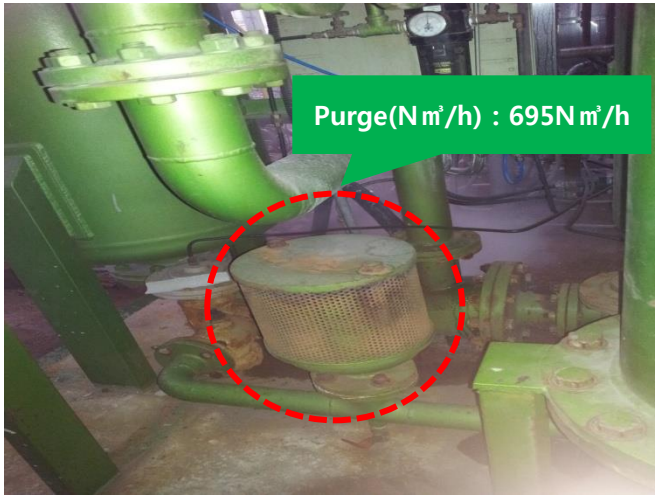
Case1. Improvement dehumidification basic unit by replacing high efficiency air dryer

A. Operation Status and Improvement plan

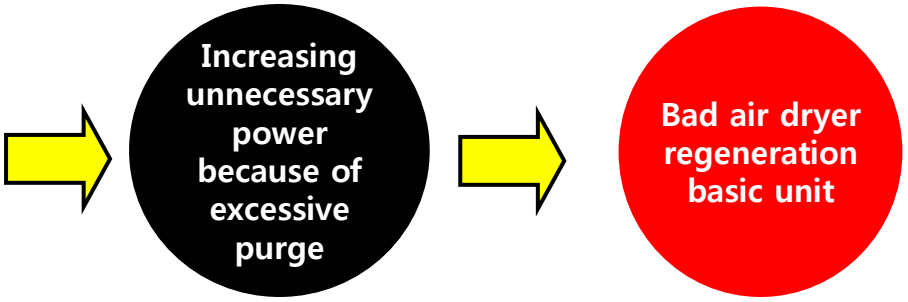
- Utility picture



● Problem Summary

Large energy consumption type -> loss is greater

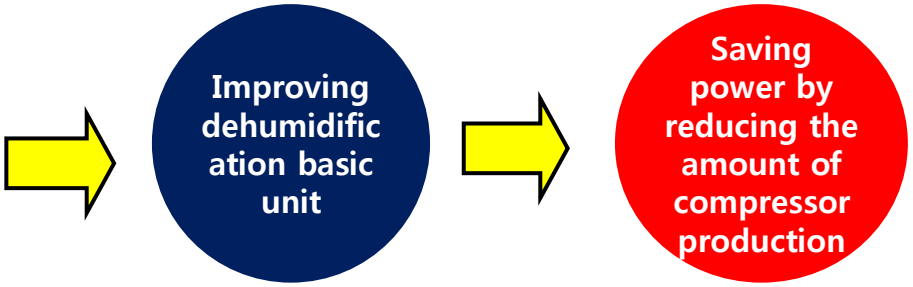
Purge consumption is huge during regeneration (39%, 52%)



● Improvement perspective

Minimizing the amount of purge

Installing high efficiency air dryer



Integrated operating 1 Combination type dryer or 1 Non-purge type dryer

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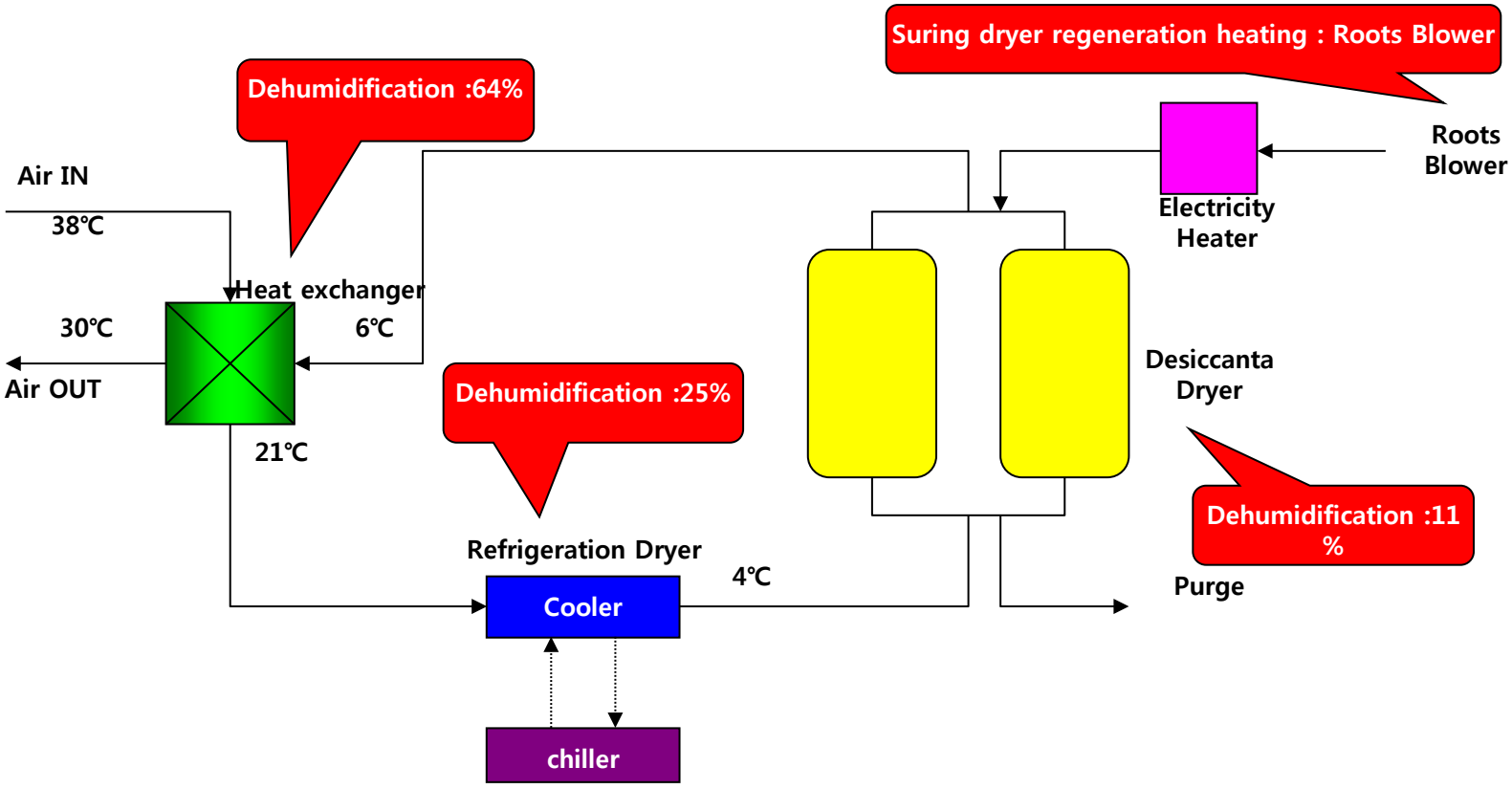
● Improvement plan 1) Integrated operating 1 Combination "Refrigeration + Desiccant" type dryer



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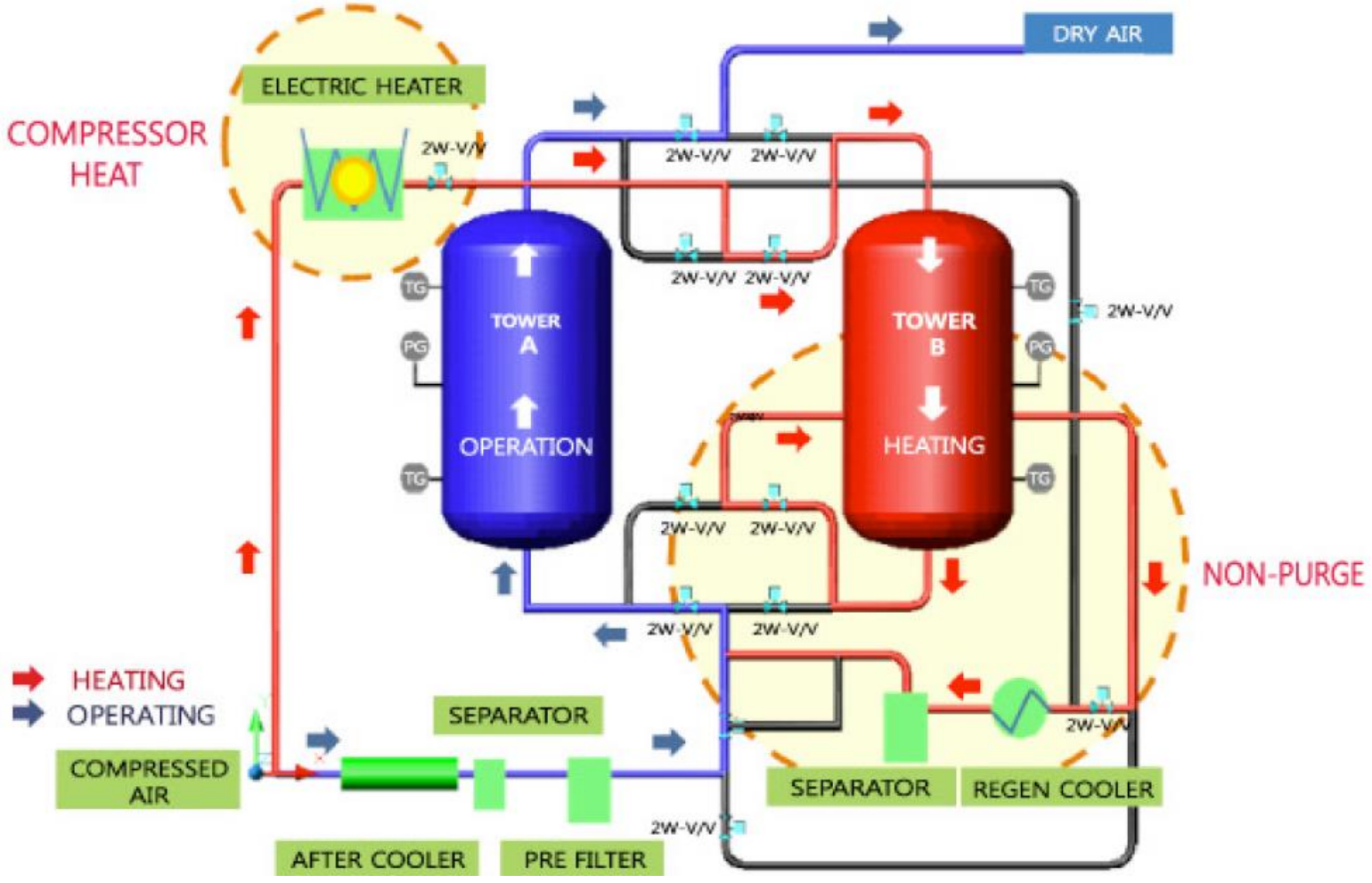
● Improvement plan 1) Integrated operating 1 Non-purge type air dryer



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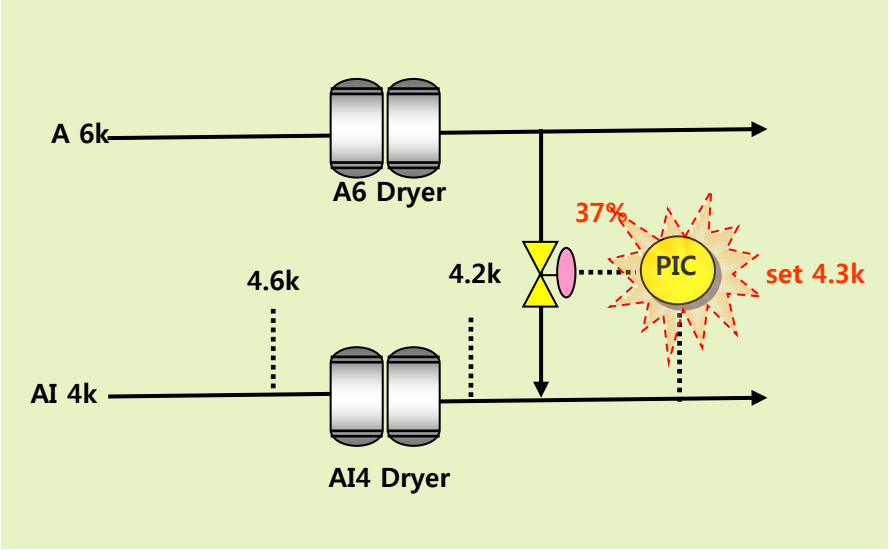
Case2. Improving excessive the amount of purge

A. Operation Status

- Diagram



- Problems
  - excessive the amount of air dryer purge
    - ☞ The amount of dryer purge is more excessive (2,128N㎥/h) than air dryer rated flow (2,008N㎥/h)
  - PCV 37% opening from A6 (dehumidification) to AI4, all of the AI4 compressed air is from A6 decompressed, so AL4 air dryer power is unnecessary power.

- Improvement plan
  - Stop the AI4 air compressor and dryer, and check the way to supply AI4 compressed air from A6

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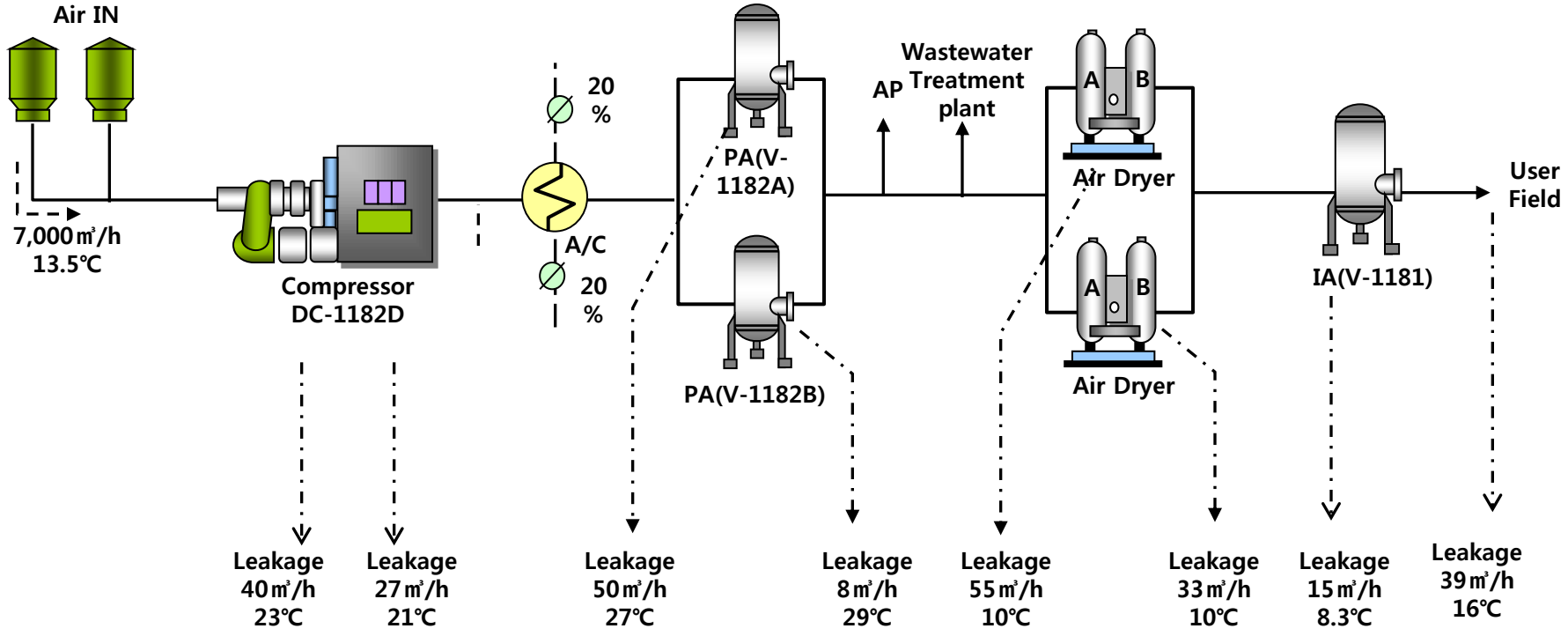
Case3. Improving Air Trap of compressed air system

A. Process status

1) Leakage of air compressor drive systems, and compressed air



8point Leakage : about267㎥/h
(Conversion 251 N㎥/h)

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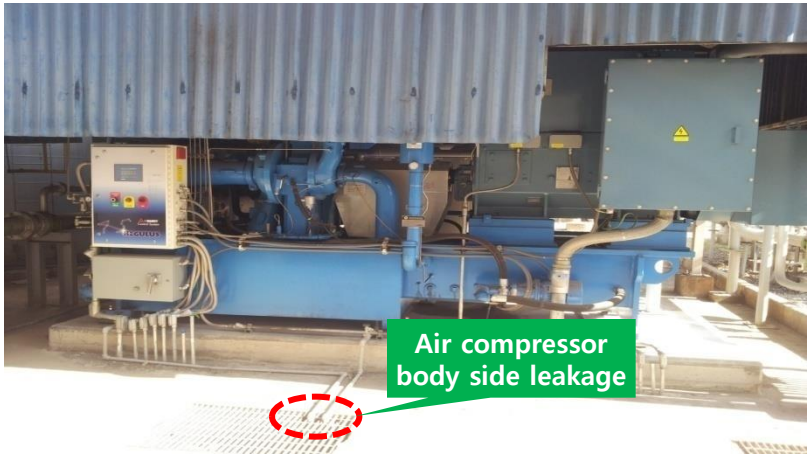
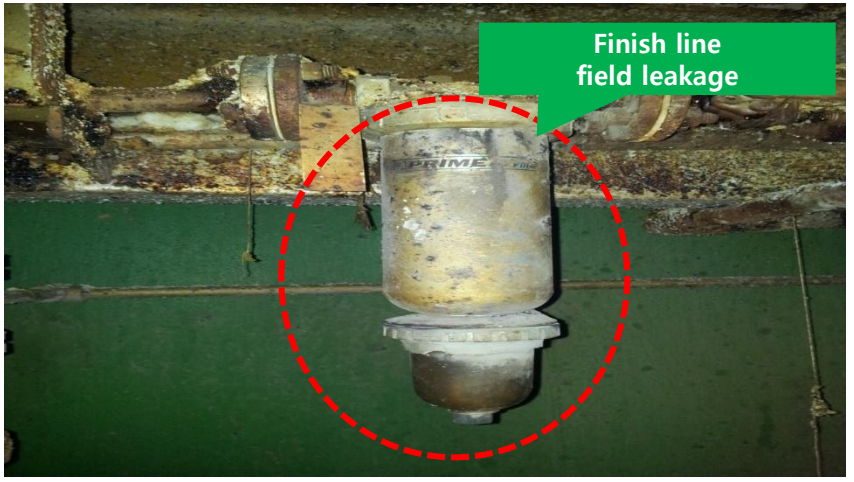
- Air compressor leakage point picture



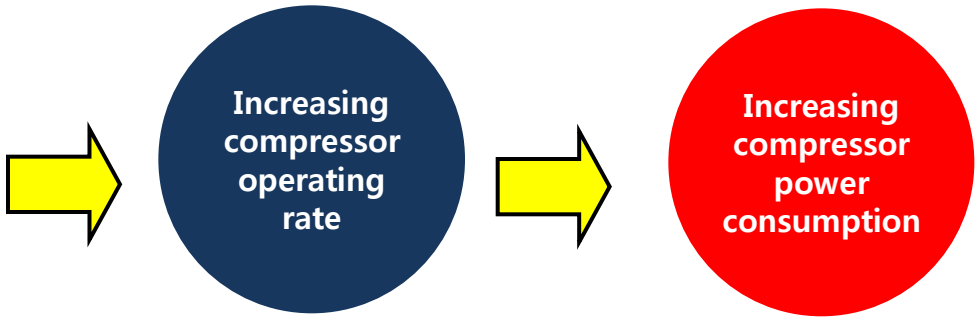


● Problem Summary

Exhausting condensate water though manual drain valve

Compressed air leakage

A mount of leakage: 251(N㎥/h)



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B. Improvement perspective and plan

1) Improvement perspective

Installing high reliability air trap

Air trap management continuously regularly

Minimizing the leakage of emission condensate water

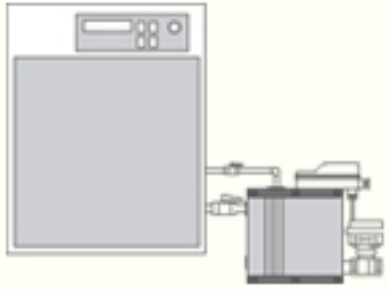
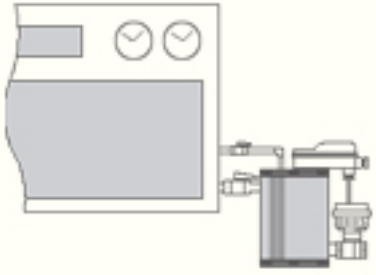
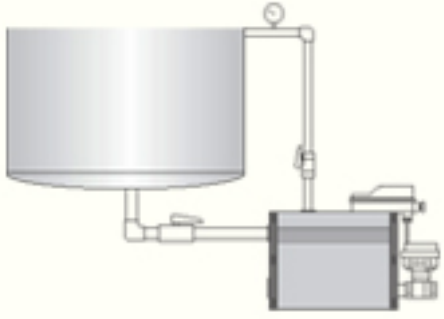
→ **Decreasing compressor operating rate** → **Decreasing compressor power consumption**

Install Level Sensor Type Air Trap

2) Improvement plan

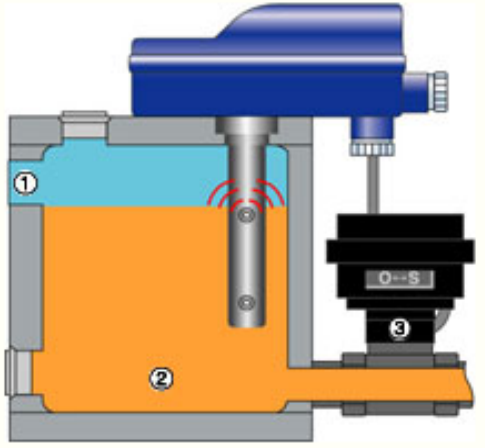
- Install Level Sensor Type Air Trap
  - Install reliable Level Sensor Type Air Trap each of the compressed air discharge locations

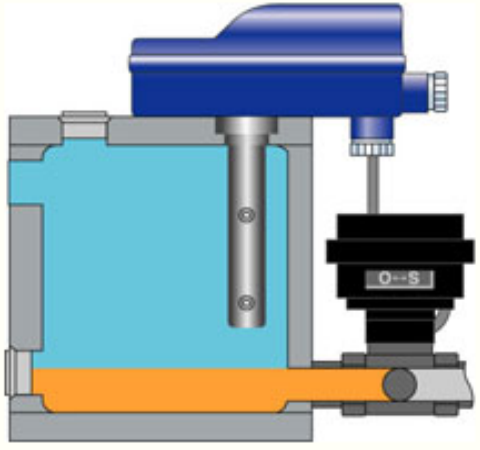
- How to install Level Sensor Type Air Trap

Compressor	Air Dryer	Air Reciver Tank	Filter
			

● Principles of Operationof Level Sensor Type Air Trap

- Condensate water gathered into the housing(2) through the inlet line(1).
- Higher the level of the housing, the sensor is detected
- If the main board give the signal, the ball valve(3) is opened and condensate water is discharged through the outlet line.





- If the water level is going down in housing, sensor is detected and the ball valve closed by signal.

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●Compressed air leakage management checklist

산팀 L2 작전 CHECK LIST

NO	공정	위치 및 내용	물질명	작업사항			조치 확인	비고
				즉시	B/D	O/H		
1	COMP'실	AIR Filter-2번 배출 플랜지부	IA		O		×	
2	blow'실	TB-11번 pcv-9 valve틈작부	IA,N2	O			O	
3	blow'실	TB-11번 pcv-10 valve틈작부	IA,N2	O			O	
4	blow'실	TB-13번 pcv-7 valve틈작부	IA,N2	O			O	
5	blow'실	TB-13번 pcv-8 valve틈작부	IA,N2	O			O	
6	SS-3번	ASV-107 실린더헤드부	IA	O			O	
7	SS-3번	ASV-107 oiler 고정부	IA	O			O	
8	SS-4번	ASV-106 oiler 고정부	IA	O			O	
9	SS-4번	ASV-106 air공급 valve부	IA	O			O	
10	chip이송	ASV-302 oiler 상부	IA	O			O	
11	chip이송	ASV-306 limiter swich부	IA	O			O	
12	pack실	T-EG실 청소용 air valve부	IA	O			O	
13	dryer	1층 청소용 air valve부	IA	O			O	
14	winder	shaft air 주입구	IA	O			O	
15	winder	core 위치조정롤러부 상,부 넛트	IA	O			O	

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3. Measuring Power Consumption

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3. Measuring Power Consumption

A. Prior Check Point

Check to allow with Personnel Possible

- Pre-contact to Personnel
- Request to open access door
- Required for the presence of Personnel

Check the Voltage is high or low

- Refrain measuring High voltage
- Check necessary instruments
- Bring the Safety Equipment

Check the Capacity(kW) / Equipment Number

- Make a list of the target to measure
- Be provided measuring list in advance
- Check field

Check to drive inverter or not

- Check operating inverter
- Check driving frequency
- Check the control scheme

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B. Visit Site to measure

1 Visit Electrical room

- **Give to personnel a list of equipment that you want to measure electrical power which is creating a list in advance.**
  - the number and name of equipment, capacity (kW), inverters driving.
- **Set an appointment date and time and notify your personnel to appointed date.**
- **Note the location of the facility and distribution of electrical rooms and switchboard.**

Precaution

- Find the working person **the day before a pre-request**, if you need to measure electrical power.
- **Promise to comply with the time**, if you have an appointment with personnel.

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2 Note switchboard meter

- **High-voltage (3,300V or 6,600V) power equipment is generally having the voltmeter, ammeter, wattmeter, power factor, etc in distribution room.**
- **You don't have to measure the power in this case, and read the displayed power data and analyze. Reaffirmation to the personnel should be considered, if there is an error in display value**

Precaution

- **Accompany with the electrical personnel**, if you visit to the substation / distribution of high-voltage.
- **Be careful about malfunction in switchboard** due to cloth or measuring equipment in indoor movement.
- **Do not operate manually without authorization** by the personnel.

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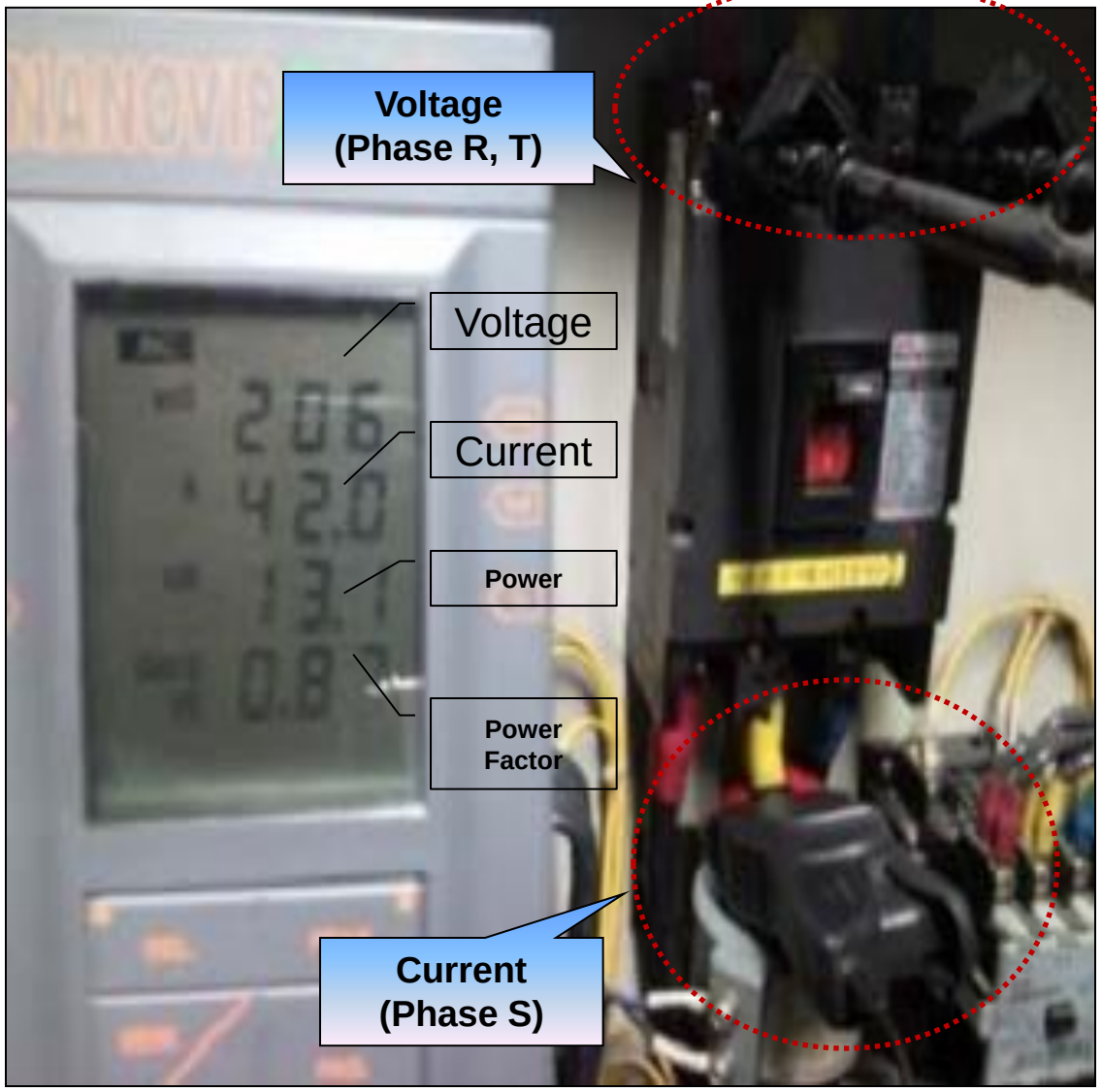

3 Measuring instantaneous low-voltage

- **Measure directly power line attached to the circuit breaker in switchboard , if you measure the power consumption of the low-voltage equipment.**
- **Typically the case of three-phase alternating current, the current meter attached to a 1-phase terminals and voltage terminals attached to the rest of the two-phase, and measured displayed values.**
- **As a rule, R, S, T of each phase current measured by the average in three-phase, you measured only 1-phase and analyze unless you have a large unbalanced state.**

Precaution

- **Be careful electric shock** when measuring, and insulated gloves should be worn for the safety.
- **Be careful that short-circuit or disconnection** of each phase for measuring to the terminal contacts.
- You should **require immediate action to the personnel in the event of an accident.**

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4 Measuring instantaneous high-voltage

- **The breakdown accident occurs if you use the low-voltage instrument directly into the primary side high-voltage (3,300V or 6,600V) equipment to measure power.**
- **In this case, measuring directly power consumption (kW) to use wiring into the power transformers (PT) and current transformer (CT) secondary-side.**
- **Contact CT to the switchboard and PT to the other switchboard to measure electric power in high-voltage.**

Precaution

- You **must take care to avoid damage or short-circuit** when attaching the line of CT and PT secondary-side wiring on ammeter and voltmeter.
- Be careful of accident, such as an electric shock when measuring and **safety gloves** should be worn

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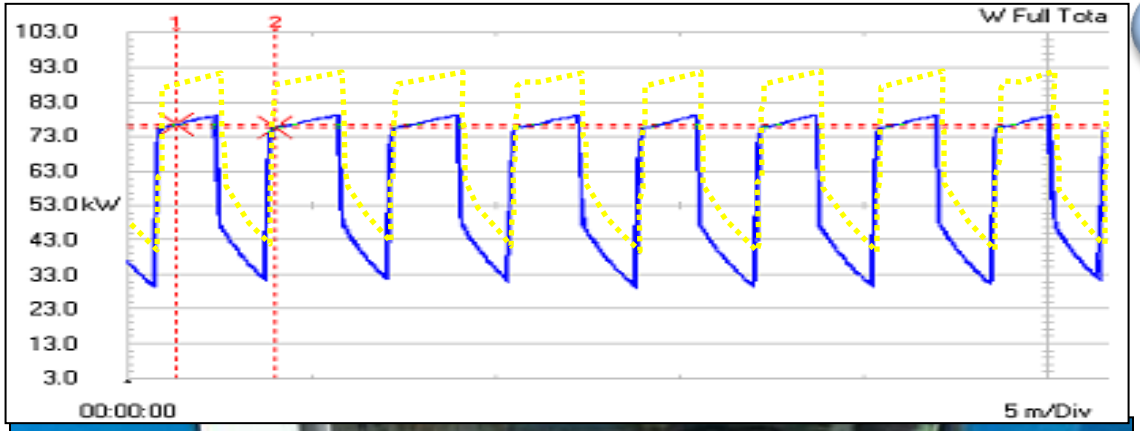

5

Measuring Continuous Power

- **Measure the power consumption continuously for determining the operation state of the equipment that occur load changes frequently such as air compressor.**
- **Check the power supply of the measuring equipment for a long time to supply power , and supply power to measuring equipment using the extension cable in around.**
- **Logging data stored on the SD Card, and analyzes it to determine the status of the operation.**

Precaution

- Leaves a note on the **instrument "On Measuring" in empty place for a long time,** after installing the instrument to measure continuous power.
- Leave the place after clean around well to **does not interfere with the passage and the safety.**

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Thank You!!