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COMPRESSED AIR PIPING NETWORK INSPECTION AND DOCUMENTATION FOR PAROC

TURKU AMK
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BACHELOR'S THESIS | ABSTRACT

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COMPRESSED AIR PIPING NETWORK INSPECTION AND DOCUMENTATION FOR PAROC

The aim of this thesis was to inspect and document the compressed air piping network in Paroc's stone wool factory in Parainen. The factory has gone through several larger building extensions and changes to the production and packing lines during the last fifty years. During this time, the compressed air piping network has also been changed, extended and in some cases rebuilt.

The review of existing documentation revealed that the drawings of the network contained contradictory information, and, in some cases, could not be trusted. New drawings that provide up to date information of the compressed air network of the whole factory had to be done.

The focus of the thesis was to clarify and compile all piping documentation into two different drawing types based on network inspection. The first drawing type is an AutoCAD drawing that shows the actual route of the compressed air network, used pipe sizes and pipe elevations in a factory layout. The second drawing type is a piping and instrumentation diagram that indicates which pipes provide airflow to devices in stone wool production process. The final results of the inspection contain information on structural problems, a network analysis and development ideas.

The drawings and presented development ideas will be used in the planning of more accurate maintenance, occupational health and safety development, future project planning and piping network development.

KEYWORDS:

Compressed air, Compressed air network, Layout, Piping Inspection, Piping and Instrumentation Diagram, P&ID

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PAINEILMAVERKOSTON TARKASTUS JA DOKUMENTOINTI PAROCILLE

Opinnäytetyössä tarkastetaan ja dokumentoidaan Paraisilla sijaitsevan Parocin kivivillatehtaan paineilmaverkosto. Tehtaaseen on viidenkymmenen vuoden aikana tehty useita laajennuksia ja muutoksia tuotanto- ja pakkauslinjoihin. Tänä aikana paineilmaverkkoa on muutettu, laajennettu ja uudelleenrakennettu.

Olemassaolevan dokumentaation tarkastus paljasti, että paineilmaverkon piirustukset olivat ristiriitaisia ja epäluotettavia. Paineilmaverkosta oli tehtävä ajantasaiset koko tehtaan kattavat piirustukset.

Opinnäytetyön päätavoite on selkeyttää ja koota putkistodokumentaatio kahteen piirustustyyppiin putkistoselvityksen perusteella. Ensimmäinen piirustus näyttää tehtaan layoutissa paineilmaverkon tarkan sijainnin, putkikoot ja putken korkeustason. Toinen piirustus on PI-kaavio, joka näyttää paineilmaverkon ilmansyöttöpisteet. Putkistoselvityksen tuloksissa esitellään verkon ongelmalliset rakenteelliset asiat, paineilmaverkon analyysi ja kehitysehdotuksia.

Piirustuksia ja esitettyjä kehitysehdotuksia tullaan käyttämään huollon suunnittelussa, työturvallisuuden kehittämisessä, tulevien projektien suunnittelussa ja paineilmaverkoston kehittämisessä.

ASIASANAT:

Layout, Paineilma, Paineilmaverkosto, PI-kaavio, Putkiston tarkastus

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LIST OF ABBREVIATIONS

Abbreviation	Explanation of abbreviation
AutoCAD	Autodesk's 2D drawing software
CB 11	Cupola Building 11
EMF	Electric Melting Furnace
ERP	Enterprise Resource Planning
FB 5	Furnace Building 5
HVAC	Heating Ventilation and Air Conditioning
P&ID	Piping and Instrumentation Diagram
PAL 5	Parainen production line 5
PAL 11	Parainen production line 11
Plant 3D	Autodesk's Piping drawing software
SAM 4.0	Kaeser's Sigma Air Manager 4.0

1 INTRODUCTION

This introductory chapter is divided into three parts: First, objectives of this thesis are explained. Second, Paroc as a company and the Parainen stone wool factory are briefly introduced. Third, a simplified version of stone wool manufacturing process is explained.

1.1 Objectives of this thesis

The aim of this thesis is to inspect and document the compressed air network in Paroc stone wool factory in Parainen. As the milestones in chapter 1.2 will indicate, Paroc Parainen stone wool factory has gone through several larger building extensions and changes to the production and packing lines in the last fifty years. During this time, the compressed air piping network has also been changed, extended and in some cases rebuilt.

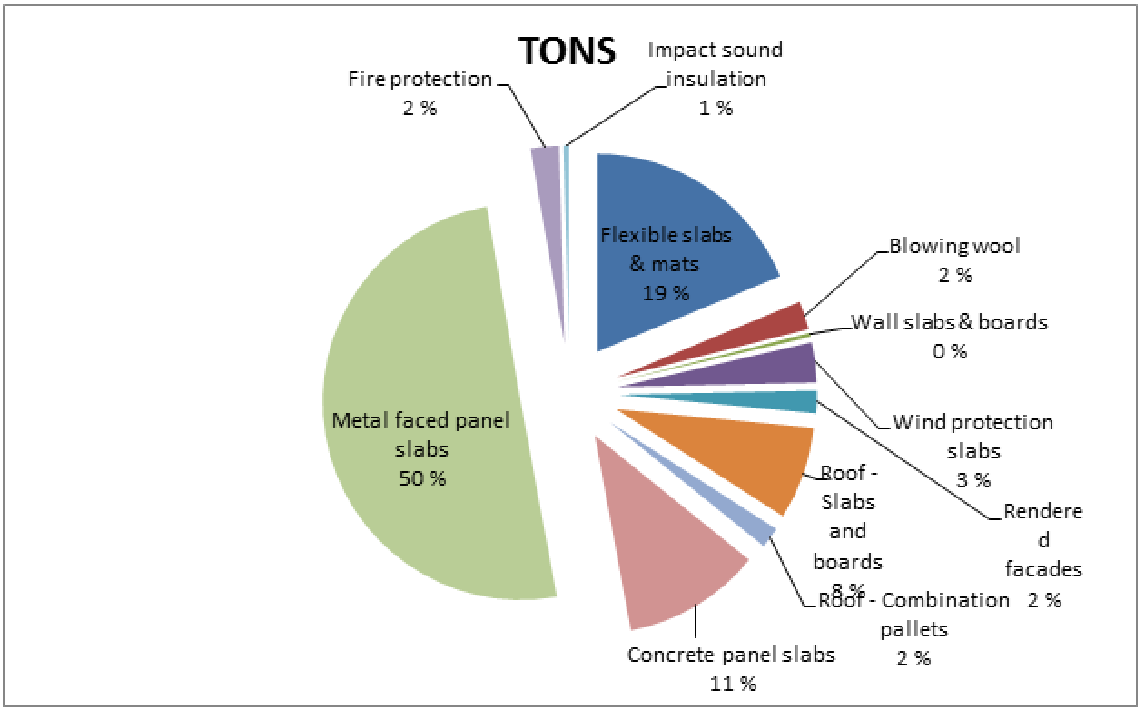
The first objective was to inspect how up-to-date the documentation of compressed air piping is. Questions that were examined: Are all of the changes to piping documented? Is every area of the factory documented in the same degree? The starting assumption was that the documentation is not fully up-to-date and if documentation is insufficient, new drawings should be done. This part of the thesis is covered in chapter 2.

The second objective was to inspect the compressed air pipeline and create documentation in form of drawings and this thesis. Two different types of drawings were demanded: first, a layout based drawing that should provide information about the actual route of the compressed air pipeline, used pipe sizes and pipe elevation. And second, a piping and instrumentation drawing (P&ID) that shows which pipes provide airflow to devices in the production process. Inspection and layout based drawing is covered in chapter 3 and P&ID in chapter 4.

The third objective was to identify any problematic issues found in the piping that is discovered during inspection phase. These possible problems would be written down and further introduced, and possible solutions would be suggested. The inspection findings, piping analysis and development ideas are covered in chapter 5.

1.2 Company introductuction

Here is how Paroc is introduced on their website: “Paroc is the leading manufacturer of energy-efficient insulation solutions in the Baltic Sea region. Paroc products include building insulation, technical insulation, marine and offshore insulation, sandwich panels and acoustic products. The products are manufactured in Finland, Sweden, Lithuania, Poland and Russia. The company has sales and representative offices in 14 European countries. Paroc Group is owned by funds advised by CVC Capital Partners and Paroc employees as minority owners” (Paroc group, 2016).



Picture 1. Parainen production unit, 2016 production in tons (Picture Tapaninaho, M.)

The production unit in Parainen operates mainly in Paroc's building insulation segment. As seen in Picture 1, in 2016, 50 % of the production was panel core insulation for panel production and 19 % was general building insulation. Some support production is done for other Paroc units, and blow wool is produced as a side product from the waste material gathered in the process.

A brief summary of milestones in Paroc Parainen stone wool factory (BI presentation 2016, 4):

- 1964, plant started production on June 2nd, 1964 with one line (L 4).
- 1966, second production line (L 5) started.
- 1978, production of blowing wool started.
- 1980, first production line was renovated (old L 4 converted to PAL 11).
- 1984, cupola of the second line (L 5) was removed.
- 1985, new building extension for second production line (PAL 5) was built.
- 1989, second production line (old L 5 converted to PAL 5) renovated and electrical furnace was installed.
- 2000, new packing end to first line and big changes to operations, automation and buildings
- 2011, common devices for packing were renovated.
- 2015, second production line (PAL 5) renovated, with new electrical furnace and new packing end installed.

1.3 Stone wool manufacturing process

Approximately 95 % of the stone wool is produced from minerals like gabbro, anorthosite and dolomite. Rest of the materials are binders, for example resin and oil. The production process is divided into eight parts: raw material, melting, collection, pre-processing, curing, cooling, processing and packing.

The right amount of raw material is dosed in a dosing unit. Stones are melted in close to 1600 °C in a cupola oven with coke or with electric melting furnace. Melted stones are fiberized and blown with compressed air into a collection drum and binder materials are added to fibers. Mat is separated from the collection drum and the mat is folded with a pendulum folder. Folded mat is hardened into its shape in a curing oven and the hardened mat is cooled down. A lining is added into some products and cooled mat is cut into predefined slabs. Final product is packed into packages or palletized packages and moved into warehouse storing area.

2 RESEARCH

Information is extensively available on compressed air generally, and equipment closely related to its production and treatment. Chapters 2.1 and 2.2 are written as simplified versions of complex processes.

In chapter 2.1, only the most essential parts in compressed air system connected to piping inspection and devices used in the Parainen factory are focused upon. For example, not every air processing equipment type is covered in detail, only the equipment that is significant to this thesis.

The compressed air system in Parainen is designed by HVAC companies. The assumption is that design was made according to standards at the time it was designed. This thesis focuses mostly on inspection and review of an existing piping, so only most crucial key elements in piping design are presented in chapter 2.2.

The piping documentation review in chapter 2.3 was taken as a part of research to give overall information of what can be expected of the actual piping inspection.

2.1 Compressed air in general

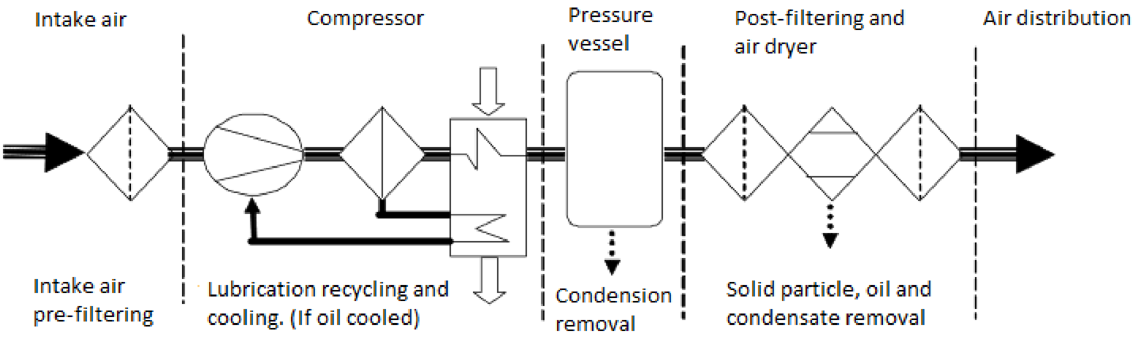
Compressed air is a user friendly medium. It is relatively safe and clean, and it can be stored. Its advantages are relative simplicity and cheap acquisition cost. These reasons usually explain why compressed air is used, considering it has clear disadvantages of low force application and operating efficiency of 5 % (Ellman et al. 2002, 8).

In most of the applications, where compressed air is used, the same could be accomplished with electric or hydraulic means. Clear advantages for compressed air uses against electric or hydraulic use are:

- Cheap components, actuators or equipment that are simple to maintain
- Clean and dry, compared to hydraulic oil
- Safe to use, no sparks, no fire or electric safety hazards
- Lightweight equipment
- Overload proof, can be loaded until equipment stops working, without being damaged

- Fast operating speed and fully adjustable force application

A compressed air system generally consists of four subsystems: a compressor, air treatment, an air distribution network and equipment requiring compressed air.

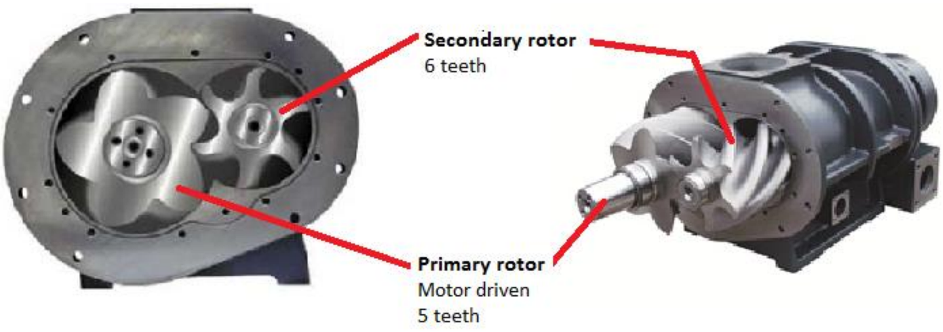


Picture 2. Typical compressed air system (Penttinen 2009, 10)

The basic principle of a compressed air system: Atmospheric air is drawn into a compressor and it is typically compressed to approximately 5−20 bar pressure. Compressed humid and impure air is processed with compressor aftercooler and air dryer to remove condensation, and with filters to remove impurities. Dry and clean air is distributed via pipes to the needed location (Penttinen 2009, 6).

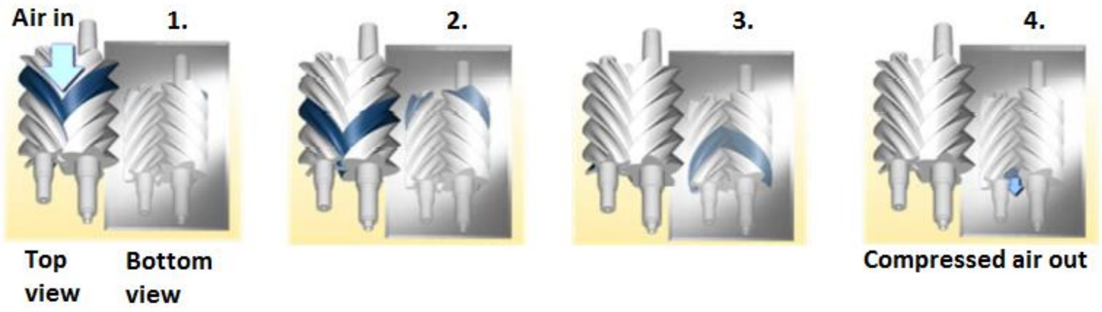
2.1.1 Rotary screw compressor

In larger factories, compressor room usually houses two or more compressors, which ensures operation, when one compressor cannot produce the needed air flow, or in compressor malfunction situations. Especially in a system of several compressors, an air management software should be used to regulate optimal compressor usage and to minimize energy consumption.



Picture 3. Kaeser rotary screw compressor (Kaeser US 2007; Kaeser US 2016)

“Rotary screw compressor operates on positive displacement principle. Two parallel rotors with different profiles work in opposite direction inside a housing that creates the compression a chamber” (BOGE Kompressoren , 42). Kaeser's Sigma screw profiles and housing can be seen in Picture 3.

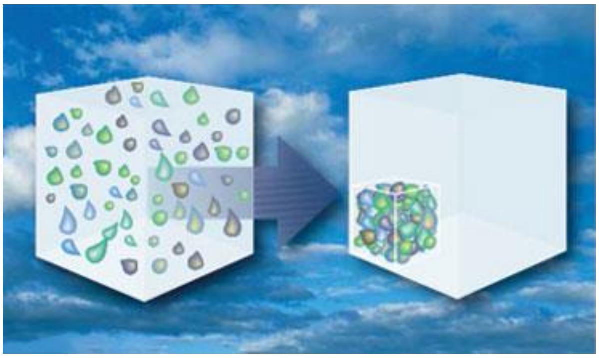


Picture 4. Compression process (Kaeser 2014a)

The intake air is compressed to final pressure in chambers, which continuously decrease in size, through the rotation of the screw rotors. When final pressure is reached, the air is forced out through the discharge outlet. The compression chambers are formed by casing walls and the meshing helical profiles of the rotors. In Picture 4, 1. Intake: The air enters through the inlet aperture into the open screw profiles of the rotors on the intake side. 2. and 3. Compression: The inlet aperture is closed by continued rotation of the rotors, the volume reduces and the pressure increases. 4. Discharge: The compression process is completed. The final pressure is reached and the discharge begins (BOGE Kompressoren, 42).

2.1.2 Compressed air treatment

In a compressor, atmospheric air is brought to a higher pressure potential through the application of mechanical energy, which results in the air molecules being compressed. In addition to the air itself, oil, water vapour and a number of other substances are also compressed. Compressed air at 7 bar has eight times more impurities than normal ambient air (Hankinson).



Picture 5. Impurities in the air compressed from atmospheric air (Hankinson)

1 m^3 of atmospheric air contains:

- **Aerosols:** Small drops of liquid formed from water and oil
- **Liquid:** Water in atmospheric humidity
- **Metals:** traces of lead, cadmium, iron
- **Solids:** Dust, sand and particles resulting from corrosion and wear

Atmospheric air quality is also dependant on where compressed air is produced. If atmospheric air is taken from next to a busy highway or heavy industry, where air quality is bad, the amount of impurities are also higher.

Condensation is the change of the physical state of matter from gas phase into liquid phase, and is the reverse of evaporation. The higher the dew point (the point at which the air is saturated with water and at which the relative humidity is 100%), the higher the amount of water that the air can hold. When the air cools down, the water is released from the air and the compressed air becomes contaminated (Hankinson).

Drying of air is the most important form of compressed air treatment. Undried compressed air damages compressed air lines and disrupts equipment function, resulting in expensive maintenance costs and production downtime. For an example: A compressor that produces compressed air 5 m^3/min, generates 30 l of water in +20 °C and 70 % humidity within 8 hours (Kaeser 2014b).

Picture 6. Condensate removal and drying (Kaeser 2014b)

Air heats up to 80−200 °C in the compression process. Aftercooler decreases compressed air temperature that results in condensation. In Picture 6, approximately 70−80 % of the condensate is removed right after compression with aftercooler of the compressor. Compressed air receiver takes in the airflow and some of the condensate collects in compressed air receiver, as volumetric flow calms down and the droplets of water precipitate. Air is cooled down close to water freezing point in the refrigeration dryer. The condensation precipitates in the dryer and is drained of. At this point 99 % of the condensate is removed in liquid form and the remaining 1 % of condensate remains as steam (Kaeser 2014b; BOGE Kompressoren, 73).

Some of the oil and impurities are removed during condensate removal process. In a final treatment phase, air travels through a filter to remove small particles and other impurities, remaining condensate and oil. ISO 8573-1 standard defines purity classes for compressed air. Purity classes consist of maximum particle size and concentration, maximum pressure dew point and maximum oil content. Level of filtering and filter type is selected based on what purity class is needed.

2.2 Piping design

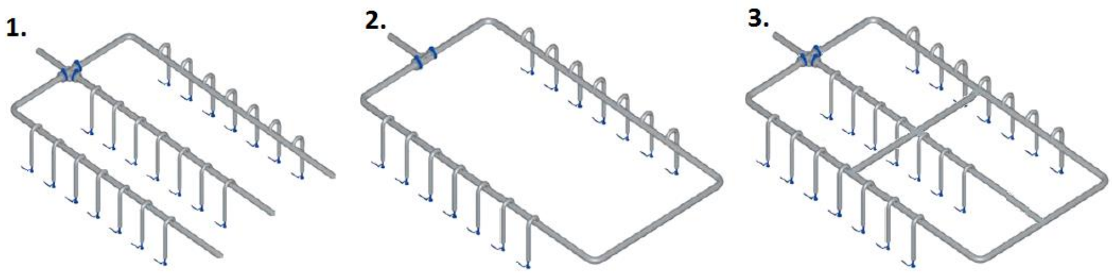
Every network is unique, and therefore, only general principles can be given. Piping design is commonly made before any piping exists or when some type of modifications or extensions are made. If done properly, highest saving in compressed air system can be made in the design process. Basic principles for piping design:

- Before actual design can start, an estimate of air consumption and required operating pressure should be calculated.
- After the estimation, system design should start from the layout, where consumption points are placed, and in what type of environment and/or type of ambient temperature air is used in.
- Pressure drop caused by the piping should be no more than 0.1 bar. Energy consumption rises 6 % when 1 bar more is produced.
- Too small pipe size can cause problems such as too high flow rate that causes problems with friction and turbulent flow.
- A larger diameter line acts as an air reservoir, further reducing the load on the compressor, and provides better capacity for a possible extension of the line.
- “Longer pipelines require larger diameters to maintain the same flow and minimize pressure drop” (Topring, 5).
- Main line should be installed to a 1:100 incline to ensure that condensate flows to the lowest point of piping, where condensate removal devices can be installed.

Same design principles can and should be used when e.g. the focus is to optimize energy efficiency of an old existing piping network. Proper layout design and right pipe size are most important factors in design process. Together with minimizing pressure drop and preventing leaking, highest savings can be achieved.

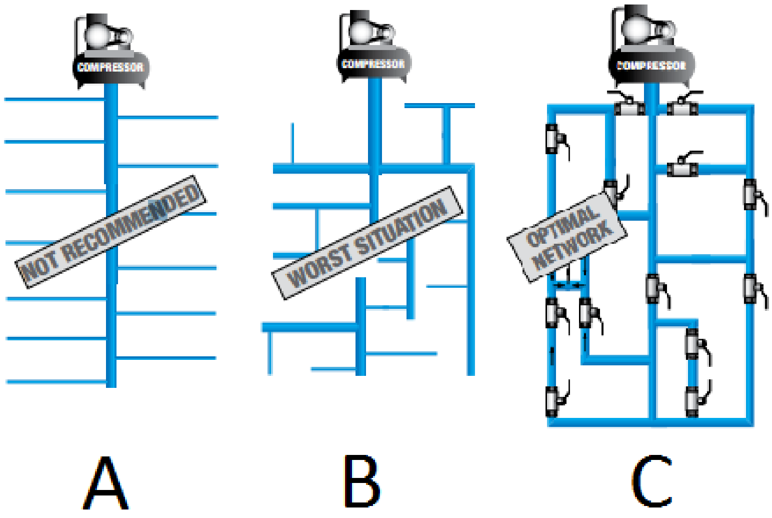
2.2.1 Designing a network

Piping network is essentially divided into three main categories:



Picture 7. Common network types (Kaeser 2014c)

In Picture 7, the following network types can be seen: 1. linear network 2. ring network and 3. combination of linear and ring, a closed loop network.



Picture 8. Common network types 2 (Topring, 3−4).

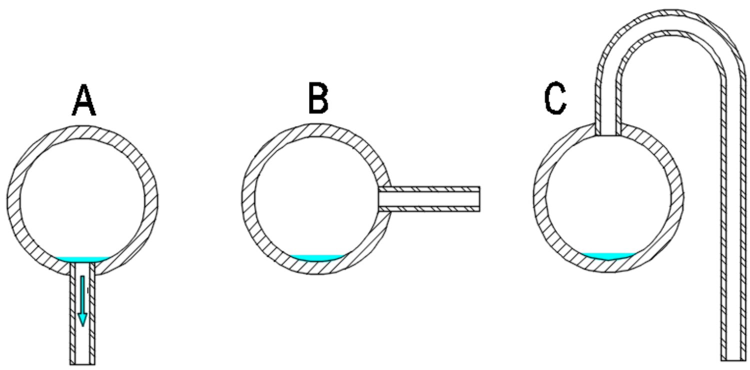
In Picture 8, A and C are in principle the same type of network as 1. and 3. depicted in Picture 7. B is an octopus network, according to Topring.

There is usually a single major pipe in linear network (Picture 7, 1. and Picture 8, A), where air supply pipes are connected. Structurally, it is the simplest and cheapest network type to build, and it is suitable for small systems. For this type of network to work properly, equipment should be placed in a decreasing order, based on consumption. Equipment with higher need for air flow should be located closest to the compressor, while ones that use less should be further away. If this order cannot be fulfilled, a compressed air receiver should be placed to balance consumption need. If some maintenance is needed to carry out e.g. in the middle of the network, airflow is cut from the rest of the network. Maintenance and extension of this network type is difficult.

A network, where each additional line and extension does not necessarily match the initial configuration, is called an “octopus” network (Picture 8, B). Linear networks often evolve into octopus networks over time. The octopus network includes the following anomalies: different airline materials; curves, reductions and enlargements without apparent reason; inconsistent diameters of air lines and installation done with no knowledge of pneumatic standards. Predicting what flow and pressure are available at any point is virtually impossible. Air flow fluctuations from varying usage of pneumatic equipment and air tools makes it even more difficult to get the right pressure and flow at any given point. This results in varying pressure and airflow conditions throughout the system, creating many problems (Topring, 3).

A ring network (Picture 7, 2.) is structurally more complex and expensive to build, but it is more suitable for larger scale operation than linear network. A clear benefit is that air flows to every point of the network from two directions, making it easier to close some areas for maintenance or extension, without disrupting airflow in other parts of the network. Pressure can be maintained more stable, and the volume it can hold is larger, making it an air reservoir.

A closed loop network (Picture 7, 3. and Picture 8, C) has all of the benefits of ring network, with more flexibility on maintenance and expansion. The loops do not need to be uniform in size. A major benefit is that some areas can easily be isolated, and the network can be divided into smaller easily manageable sections. “This type of network is often the ideal situation for compressed air distribution systems, providing the balance between flow and pressure required to provide the most efficient distribution of compressed air” (Topring, 4).



Picture 9. Cross section of major and connecting pipes

Three most typical ways of pipe connections to major pipe network are shown in Picture 9, blue depicting condensation water. Compressed air is commonly dried, so in principle, connecting pipes can be installed below the major pipe network. Some networks may contain old condensation, so connection A should only be used if condensate drain is located below. B connection is relatively safe from condensation and C connection with a gooseneck is the safest. Although most devices have a filter before a straight connection to a device, commonly a gooseneck connection is used.

2.2.2 Pipe sizes, materials and fittings

Pipes are commonly marked in DN size in Europe. DN is short for the French term diamètre nominal (nominal diameter) that describes inside diameter of a pipe as a approximate size that might vary from the actual size given. E.g. DN 25 pipe has a inside diameter of 27.2 mm, which is close to 25 mm. Table 1 shows the most common sizes used in compressed air systems.

Table 1. DN pipe sizes (BOGE Kompressoren, 159)

Nominal pipe width acc. to DIN 2440 [Inches]	[DN]	Outside diameter [mm]	Inside diameter [mm]	Inside cross-section [cm2]	Wall thickness [mm]
1/8"	6	10.2	6.2	0.30	2.00
1/4"	8	13.5	8.8	0.61	2.35
3/8"	10	17.2	12.5	1.22	2.35
1/2"	15	21.3	16.0	2.00	2.65
3/4"	20	26.9	21.6	3.67	2.65
1"	25	33.7	27.2	5.82	3.25
1 1/4"	32	42.4	35.9	10.15	3.25
1 1/2"	40	48.3	41.8	13.80	3.25
2"	50	60.3	53.0	22.10	3.65
2 1/2"	65	76.1	68.8	37.20	3.65
3"	80	88.9	80.8	50.70	4.05
4"	100	114.3	105.3	87.00	4.50
5"	125	139.7	130.0	133.50	4.85
6"	150	165.1	155.4	190.00	4.85

Pipes used in compressed air systems are normally divided into three material categories: steels, non-ferrous and plastic. The material choice is made based on preferred criteria that can be: Protection against corrosion, maximum operating pressure and temperature, low pressure loss and low installation or material cost.

Table 2. Pipe material comparison (according to BOGE Kompressoren)

Pipe type/material	Corrosion risk	Max operating pressure	Max operating temperature	Flow resistance	Easy to install	Cost	Weight	Size availability
Threaded steel	Yes	High	High	Yes	Yes	Low	High	High
Seamles steel	Yes	High	High	Some	No	Moderate	High	High
Stainless steel	No	High	High	No	No	Moderate	High	High
Copper	No	High	Moderate	No	Yes	High	Moderate	Low
Aluminium	No	High	Moderate	No	Yes	Moderate	Low	Moderate
Plastic	No	Low	Low	No	Yes	Low	Low	Low

Seamless and stainless steel pipes are either connected with welded flanges or welded together. Non ferrous materials in Table 2 are either threaded or welded. Connecting method varies from glueing to threading, based on plastic material used.

Pipe weight depends on material used and support brackets are to be selected based on weight, placement of the pipe and material. Supports are not inspected in this thesis.

2.3 Piping documentation review

Documentation on compressed air pipelines and piping was a collection of drawings that were made from 1966 to 2011. A bulk of piping drawings were made by external companies that were unconnected to each other. The level of documentation varied between paper and actual AutoCAD drawings, and not all of the drawings were updated before or after rearrangement or revision, or after an installation of new machines. No clear “big picture” of the actual state and type of piping network was available, due to the sheer amount of drawings made during a fifty-year period, and because one area was depicted in one drawing and next area in a different drawing, with no clear connection between the drawings could always be found.

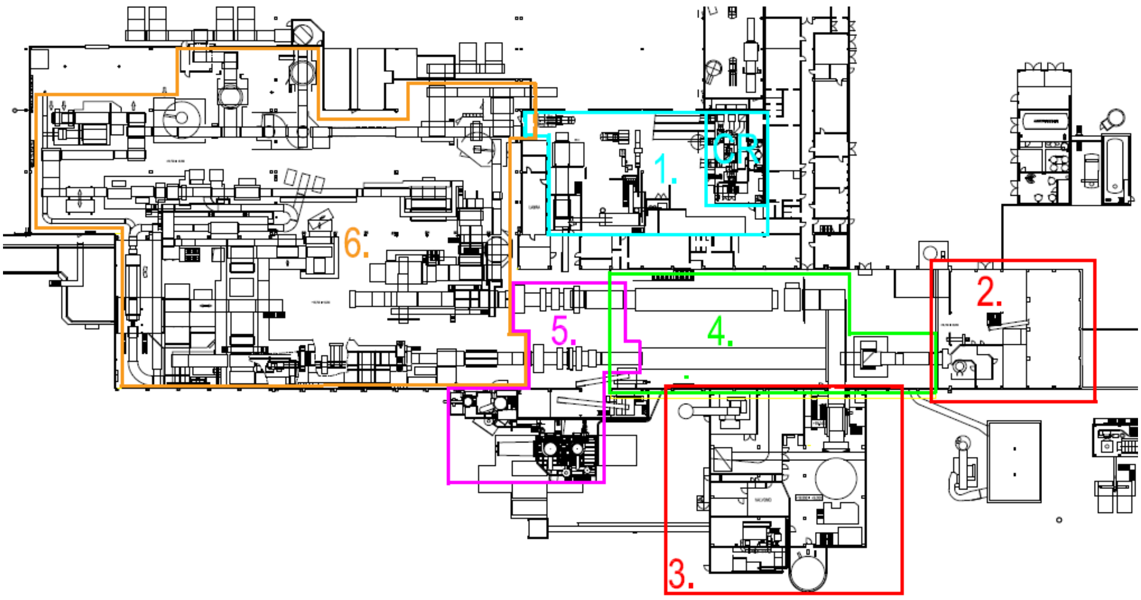
Based on piping documentation inspection, it was clear that the piping has been reorganised and extended several times during an almost fifty-year period. During this period, documentation did not always follow with the changes and therefore, drawings were contradictory to each other. Because of this contradiction, some of the drawings could only be used as a general guideline of pipe location, while doing the pipeline inspection. Most of the drawings focused only on a separate area of the factory, and only an out-of-date drawing of the whole factory drawn in 1986 was available. Because of the lack of a whole factory piping drawing, and the contradiction between the drawings, reading of the drawings and finding out "the big picture" was difficult. New drawings should be done to counter this problem.

3 LAYOUT BASED PIPELINE INSPECTION AND DRAWING

This chapter focuses on the essential core of this thesis, the inspection and drawing. Factory layout, elevation marking and working method are introduced before the actual inspection phase is explained. The inspection is first divided into sub chapters (3.4) and explained in a simplified manner and later analyzed in chapter 5.

3.1 Factory layout and areas

There are two versions of the layout, a detailed one and a simplified “blocky” version. It was decided that the simplified version would be used for piping drawing because it might be harder to differentiate pipes from the machines and structural elements like walls and pillars.

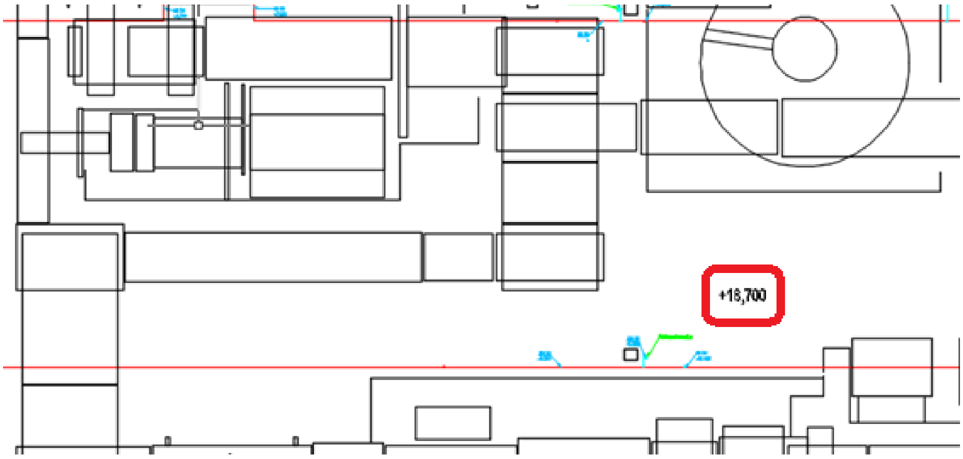


Picture 10. Machine floor layout with marked areas

The factory can be divided into six main areas, which are marked in Picture 10: compressor room and blow wool (CR and 1.) cupola building 11 (2.), furnace building 5 (3.), curing (4.), processing (5.), and packing (6.). All of the areas will be covered in the same sequence in chapters 3.4 and 5.2.

3.2 Factory floors and elevation marking

The factory operates on eight main floors. Cupola building 11 (PAL-11) is divided into cellar, machine, raw material, spinner and oven floor. Furnace building 5 (PAL-5) is divided into cellar, spinner, oven and raw material floor. Rest of the factory operates on cellar and machine floors.



Picture 11. Example of an old elevation marking

Altitude from sea level was used to represent elevation markings in factory layout. However, this way of marking elevation is quite problematic and uninformative. If a pipe in Picture 11 would have an elevation marking +18,700, it would be obvious that it has an elevation of two meters from the floor. However, with a fast glance of the layout drawing, it might not be this simple, and this way of marking is counter intuitive.

Table 3. Old and new altitude markings

Name of the floor	Altitude from sea level (mm)	Altitude from factory zero point (mm)
Cellar	13500	0
Machine	16700	3200
PAL 5 Spinner	18500	5000
PAL 5 Oven	23000	9500
PAL 5 Raw material	28000	14500
PAL 11 Raw material	18000	4500
PAL 11 Spinner	19170	5670
PAL 11 Oven	22970	9470

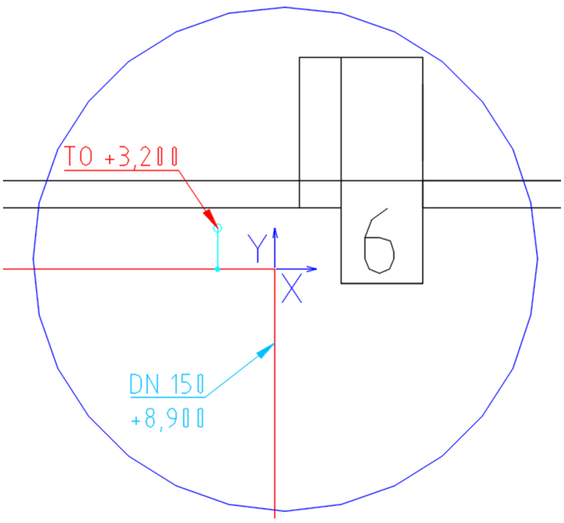
It was decided that cellar level would be used as a zero point for elevation marking of building floors and piping. NThe nw way of marking shows the old and new altitude, for example +16,700 = +3,200. Table 3 shows elevations of all major floors. Altitude from factory zero point values would be used when marking pipe and floor elevation in the drawings.

3.3 Working method

The piping documentation review revealed that old drawings could not be fully trusted in terms of pipe location. It was also apparent that pipes would travel from floor to floor in most areas of the factory. Because of many changes within the factory layout, it could be expected that sometimes pipes would seem to lead nowhere or be done in a strange manner. Due to forementioned reasons, inspection and drawing of the pipeline should be done in three phases to ensure all areas are inspected systematically.

As the first phase, a general overview of piping was performed to give some estimation of location and extent of the pipeline. As it is only an overview, this phase will not be covered in this thesis.

In the second phase, inspection and drawing has to be done simultaneously, so that all floors and areas are systematically documented. Inspection was done one area at a time in the same sequence as can be seen in Picture 10. In chapter 3.4, piping of each area is introduced in a general level and later analyzed in more detail in chapter 5.



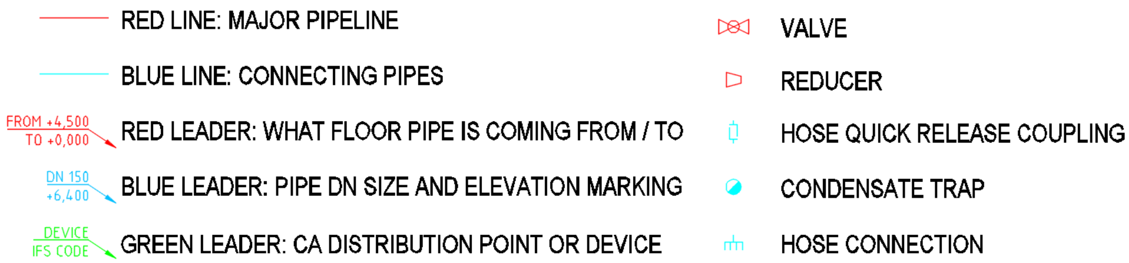
Picture 12. Measuring example

Since the inspection was made to an existing piping with the emphasis on knowing approximate pipe location, a minimum measuring accuracy was agreed to be from 50 to 100 mm. Bosch 70 DLE distance laser measure was used to provide adequate accuracy and simplicity to measuring. Measurements were made from the center of a pipe (Picture 12, red lines) to a factory wall (Picture 12, Y), support pilar (Picture 12, X) and floor. Pipes were first drafted to a paper layout and later drawn with AutoCAD. Pipes were drawn with nominal pipe sizes and with an elevation marking. Furthermore, in quite many cases, pipes went to another floor, and it was decided that these pipes should also be marked (Picture 12, cyan line to +3,200). To simplify the drawing process and make reading of the drawings easier, pipes are drawn in a right angle, although pipes have been installed with standard 90 ° elbows.

The third phase was a side product of inspection phase, where possible problematic issues or solutions would be identified and documented. The third phase with development suggestion is covered in chapter 5.

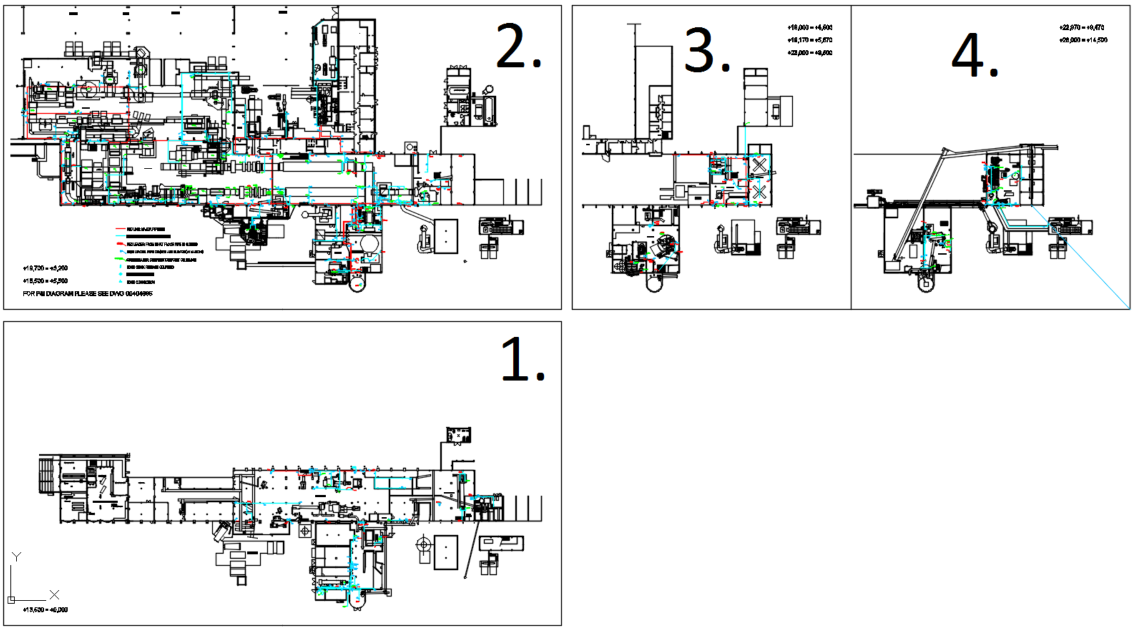
3.4 Inspection and drawing of the pipeline

The inspection was completed in three stages. First, major pipeline was inspected, so that overall knowledge of the pipeline route could be used as a basepoint for later stages. Second, connected piping from the major pipeline was inspected, which showed actual air distribution points. Third, devices connected to the compressed air network, which would later be used in P&ID, were identified.



Picture 13. Linetypes, leaders and drawing marks

Layout based piping drawing is to be used mostly for internal purposes, and it was agreed that that Paroc’s drawing style could be used. Layout has been drawn into A0 paper size, which is 841 x 1189 mm. Because of the large scale and paper size, different line types and leaders would be hard to read when printed on an A3 paper for example. This lead to color coding (Picture 13), that is not strictly based on any standard, but allows a differentiation between lines and leaders that have different meanings.

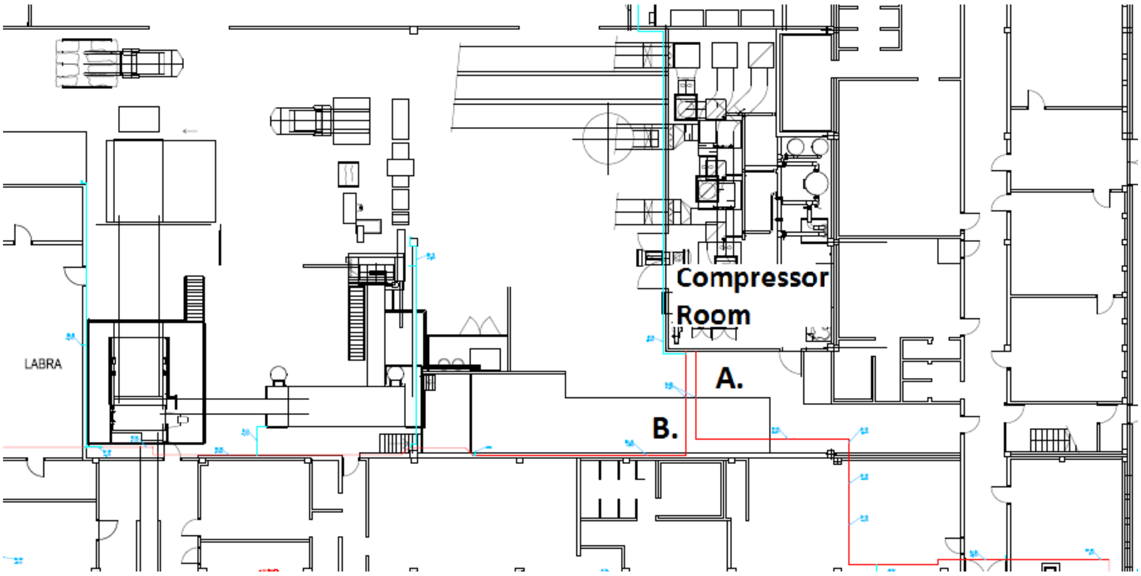


Picture 14. Four layouts added in one drawing

Layout based piping drawing was made with AutoCAD 2015 to four existing factory layouts of cellar floor (Picture 14, 1.), machine and PAL 5 spinner floor (Picture 14, 2.), PAL 11 spinner and PAL 5 oven floor (Picture 14, 3.) and PAL 11 oven and PAL 5 raw material floor (Picture 14, 4.). All of these four layouts were combined in one drawing file to make it easier to find pipes that travel from one floor to another. For printing purposes, drawings 1 (appendix 1.) and 2 (appendix 2.) are individual and 3 and 4 (appendix 3.) are combined into the same printing tab.

3.4.1 Compressor room and blow wool

Compressor room generates all compressed air currently used in the factory with three Kaeser compressors that are controlled with Sigma Air Manager 4.0. SAM 4.0 also monitors all Kaeser devices in the compressor room.

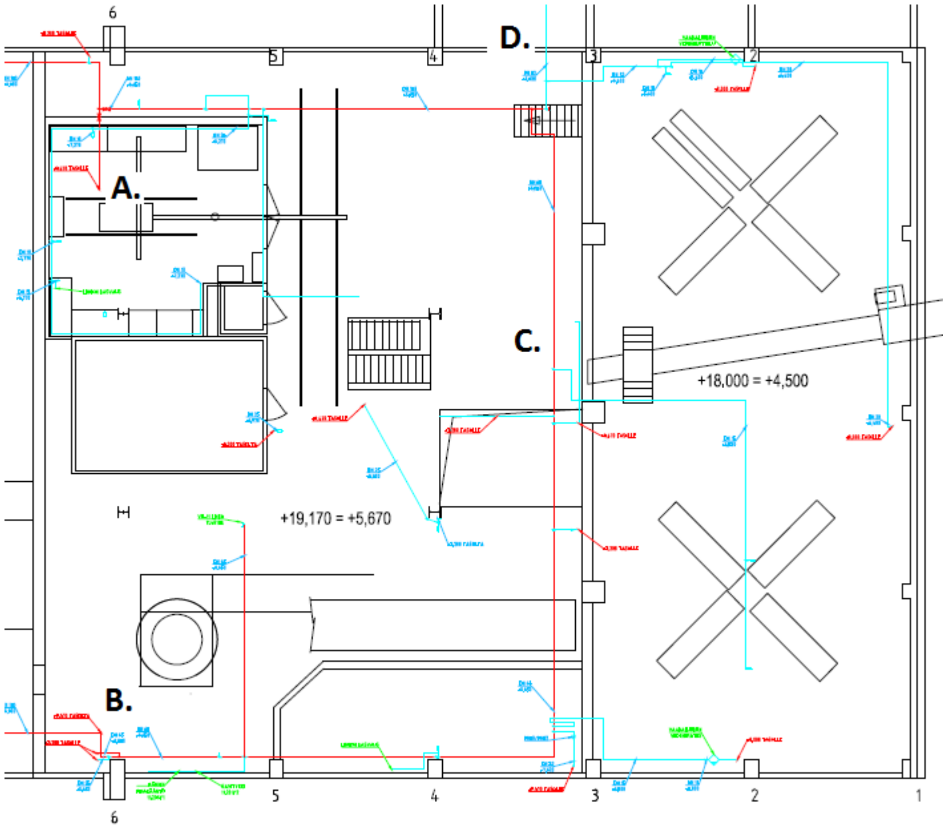


Picture 15. Compressor room and blow wool areas

To have a base point, the inspection started from the compressor room (Picture 15) and continued linearly following the main pipeline. Pipeline A., DN 150, continues through the curing area to cupola building 11; and pipeline B., DN 150, goes next to the blow wool area towards processing and packing. There are three devices in the blow wool area that require air, while the rest are quick release couplings.

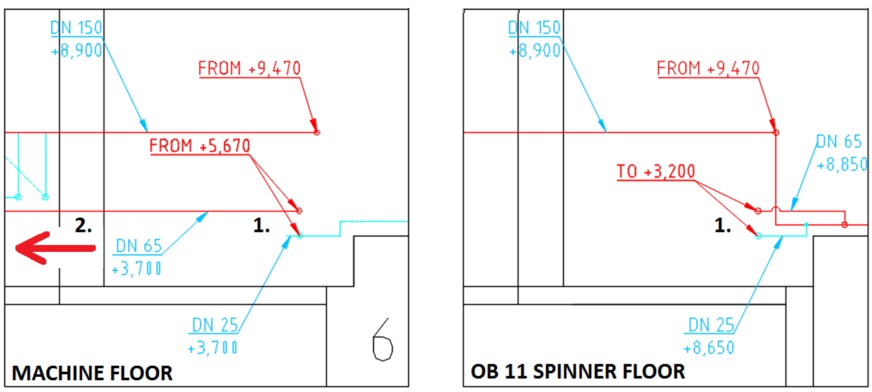
3.4.2 Cupola building 11

Production of stone wool for line 11 starts in CB 11, where raw material is dosed, melted in coke cupola furnace, spinned and formed to a mat in collection drum, and moved towards curing area. The main devices requiring compressed air are raw material dosing, spinner and flue gas treatment. There are also maintenance, support and safety equipment in CB 11. The spinner uses continuously substantial amount of volumetric flow and is the highest consumer of air in CB 11.



Picture 16. CB 11 spinner floor

In Picture 16, major pipeline DN 150 travels from curing area to CB 11 spinner floor and continues up (A.) to oven floor and comes back down (B.) and continues to the curing area. DN 65 pipe (C.) creates a closed loop in the area. Air to binder system (D.) is taken from the CB 11 network.

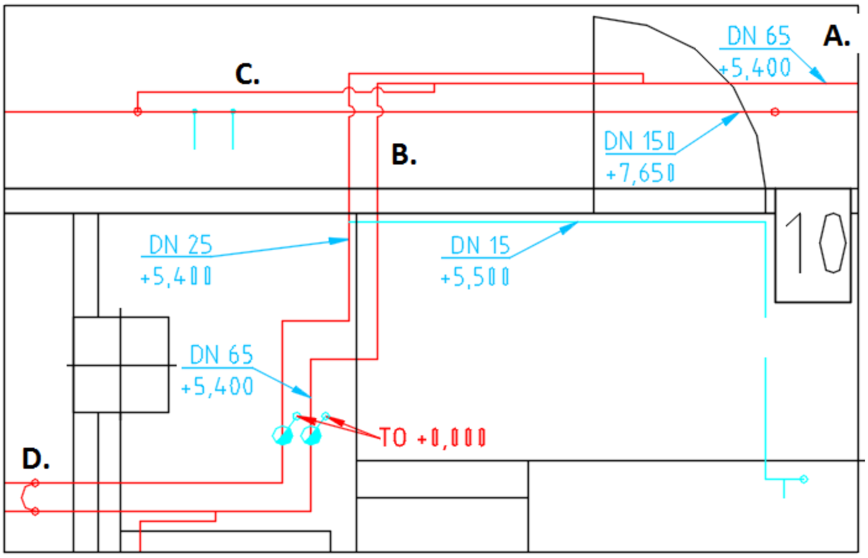


Picture 17. Closed loop connection towards FB 5

In Picture 17, a DN 65 (1.) pipe comes down from spinner to machine floor and travels towards (2.) FB 5. This pipe is part of the closed loop that supplies air to FB 5.

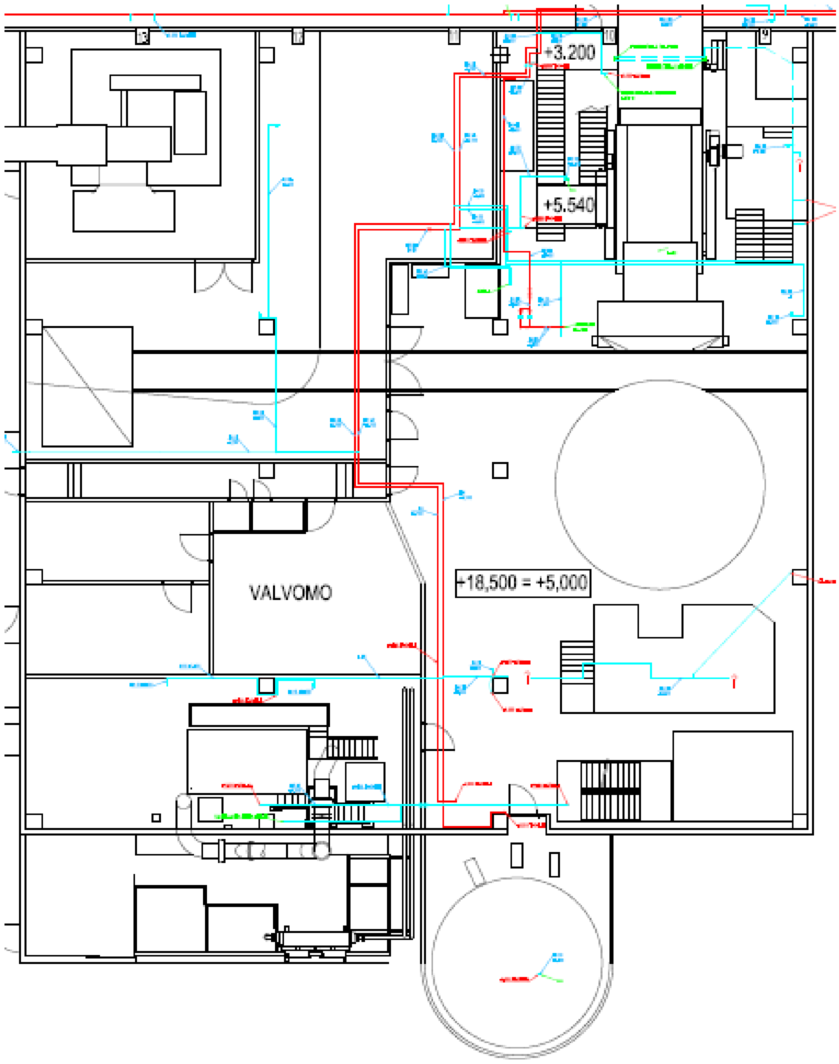
3.4.3 Furnace building 5

Line 5 starts from FB 5. Raw material is melted with electric melting furnace, spinned and formed to a mat in collection drum and conveyed towards curing area. Air consuming devices are similar to CB 11, but there are more support and safety equipments in FB 5. Also in this area, spinner is the highest consumer of air.



Picture 18. FB 5 pipe connection

Picture 18 shows connection points to FB 5. Pipe A. is the same (DN 65) pipe as in Picture 17, 2. As for B., two main pipes (DN 62 and DN 25) are connected to pipe A. and pipe C (DN 65). That makes a closed loop to (DN 150) major pipeline. Only loop in FB 5 is D., where FB 5 main pipes are connected.



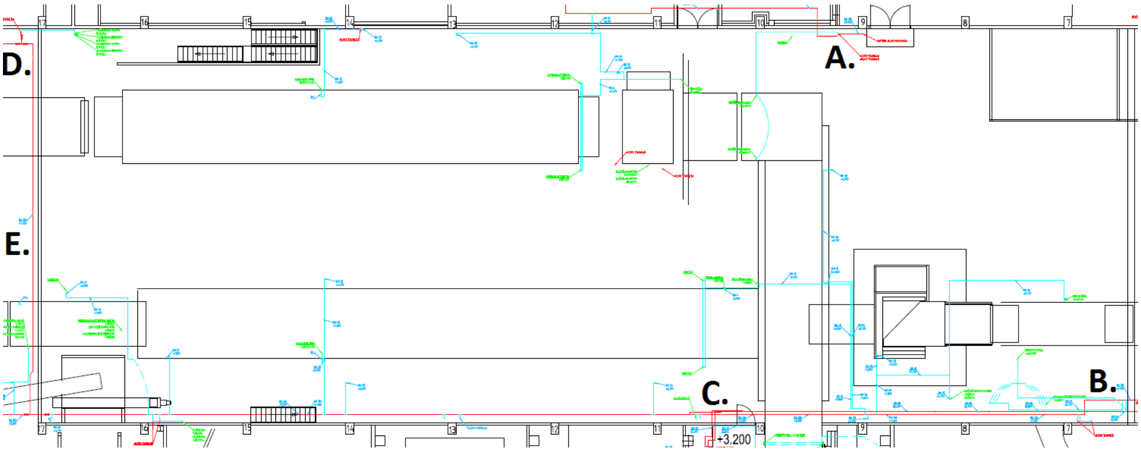
Picture 19. FB 5 spinner floor

In CB 11, major pipeline was part of a closed loop. In FB 5, there are only two connecting pipes from the major pipeline that can be considered as FB 5 major pipes. Piping within FB 5 is not designed as a closed loop, although there would be space available to do so. The reason why FB 5 piping is designed as a linear network is unknown.

Piping inspection in FB 5 area was done differently than in other areas, as it was hard to differentiate which pipe is a main pipe and which is a connected pipe, so all pipes were inspected at the same time. Some pipes had a blue sticker or a spray painted blue marking for compressed air, but FB 5 area was also considerably more dusty and unclean than other areas of the factory, which added a problematic element on finding the right pipes under the dust.

3.4.4 Curing

Conveyed mats from lines 5 and 11 are folded, flattened and hardened to desired thickness. Mats are cooled before cutting in the next area. Typical devices requiring air consumption in this area are safety, lubrication and height adjustment devices.

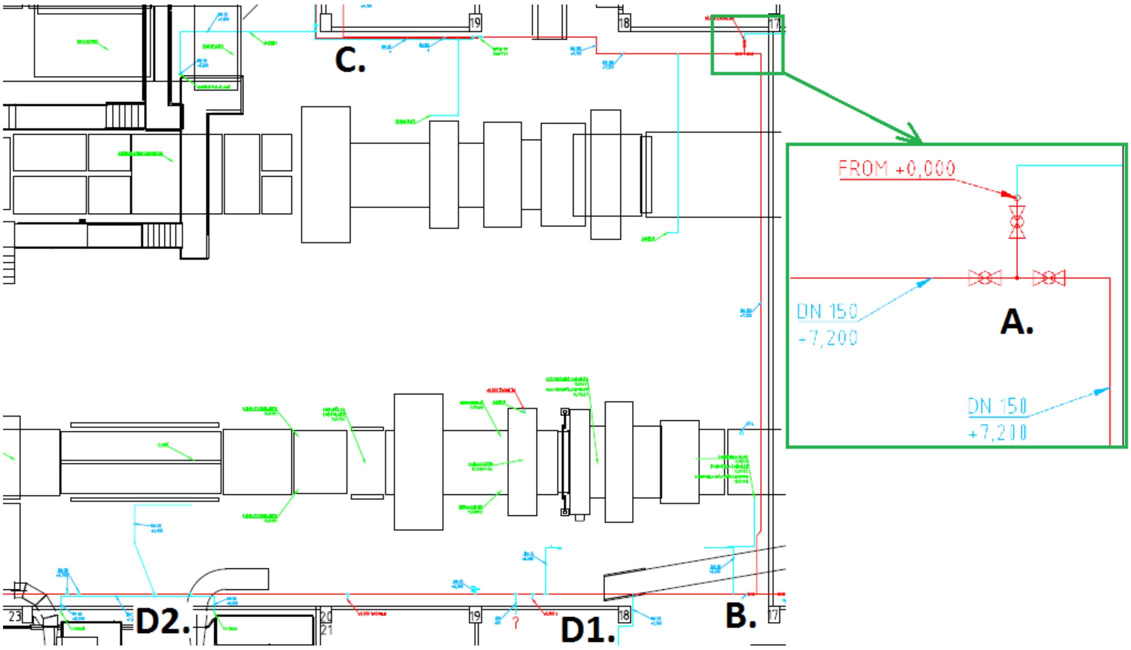


Picture 20. Curing hall machine floor

Picture 20 shows that curing hall connects major pipeline (DN 150) from compressor room in point A., where it has a T-connection down (DN 100) to cellar floor and (DN 150) up and towards CB 11. The major line comes from CB 11 from point B. and makes a connection to FB 5 in point C, as seen in Picture 18. A line from cellar floor comes up in point D. and connects to a closed loop, point E, in processing area.

3.4.5 Processing

Cooled mats are cut with longitudinal and width saws into predetermined sized slabs, and are then cleaned and conveyed towards packing. Saws, dust removal, height and width adjustment devices are most typical devices in this area. Dust filter units are the largest consumers of compressed air in processing area.

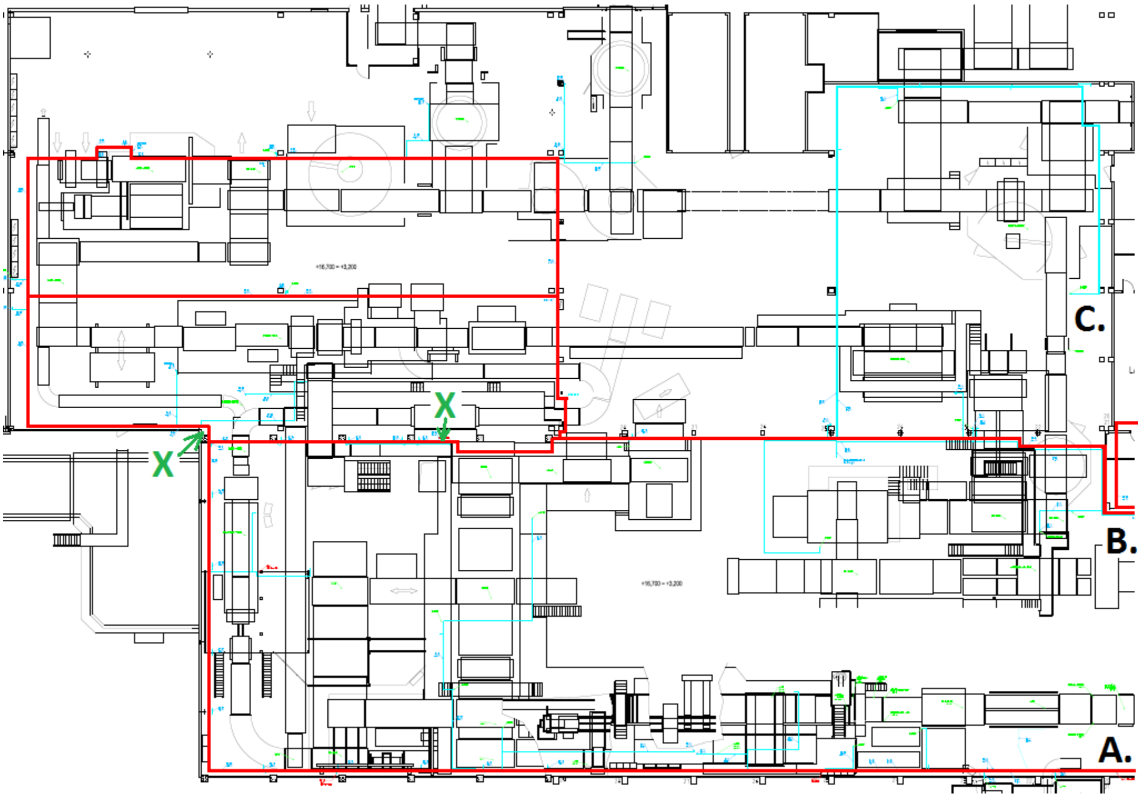


Picture 21. Processing area

In Picture 21, connections from curing hall are at A. and B. points. In point A., major line (DN 100) from cellar floor is connected with a T-connection to major lines (DN 150) in machine floor. Point C. connects major line to blow wool area (Picture 15, line B). D1. is PAL 5 dust filter unit and D2. is dust filter unit for PAL 11.

3.4.6 Packing

Cut slabs are conveyed to one of several packing lines, depending on size and desired packing method. The whole packing area is highly automatized with robots, height adjustable conveyors, turning conveyors, grabbing devices, etc. Packing as a whole consumes compressed air constantly.



Picture 22. Packing area

In Picture 22, major line (DN 150) continues from processing area at point A to packing and the loop ends to point B. At point C., DN 50 pipe ends to a distribution point and does not close a loop. In points that are marked with a green X, pipe size is reduced from DN 150 size. This means that upper left loops and the pipe ending at point B main line is reduced to DN 50 pipe size.

Packing was the last inspected area. Devices that use compressed air were checked area by area with the help of an area manager and maintenance personnel. Checked devices were marked to a layout based drawing and would be used when a P&I Diagram was drawn.

4 PIPING AND INSTRUMENTATION DIAGRAM

Piping inspection and drawing were completely done before the drawing of the P&I diagram to make the drawing process easier. P&I diagrams are very different in function, compared to layout based pipe drawings, as is stated in the lucidchart website: “A piping and instrumentation diagram, or P&ID, shows the piping and related components of a physical process flow. For processing facilities, it is a graphic representation of key piping and instrument details, control and shutdown schemes, safety and regulatory requirements and basic start up and operational information. P&ID's are a schematic illustration of the functional relationship of piping, instrumentation and system equipment components used in the field of instrumentation and control or automation. Since P&ID's are graphic representations of processes, they have some inherent limitations. They can not be relied on as real models, because they are not necessarily drawn to scale or geometrically accurate” (Lucidchart).

There was no process overview P&ID available, only P&ID’s of smaller process points. A simplified overview diagram was ordered that shows piping connected to an assembly of devices or a device. This diagram would be used alongside process flow sheets that more accurately show device coding, and therefore, it would be drawn to a more simplified form. If needed, this P&ID would later be used as a groundwork on which new piping documentation would be done.

4.1 Requirements

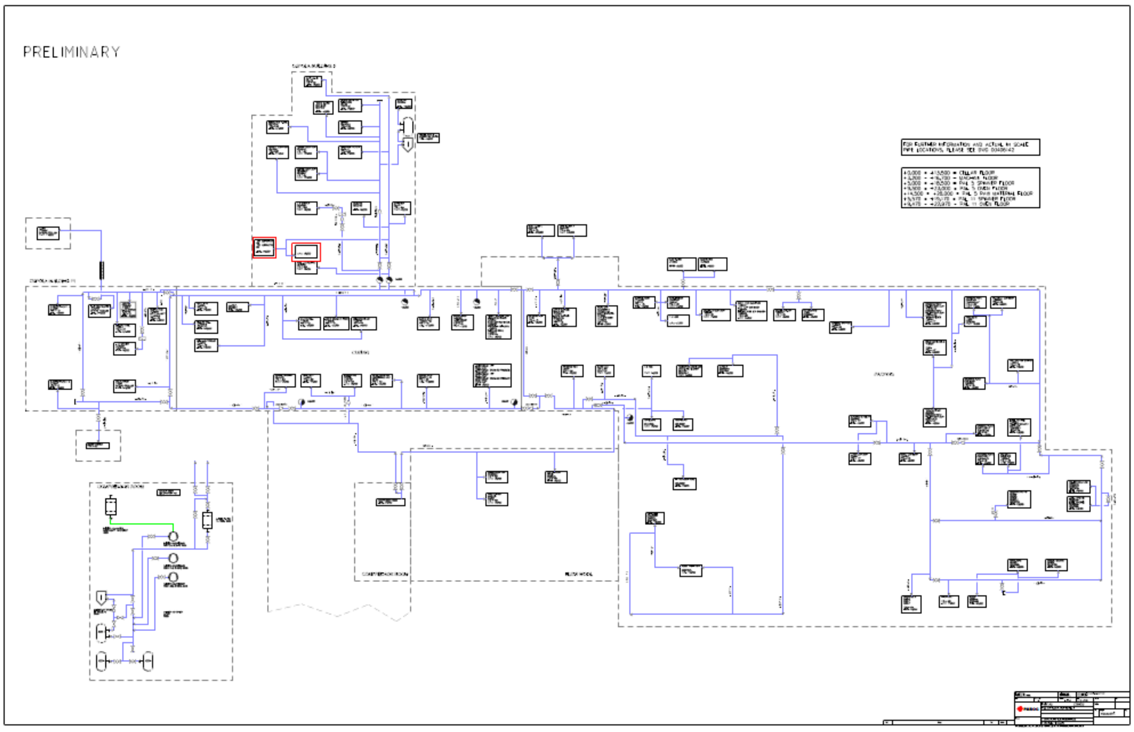
Key requirements:

- Devices
  - Show devices in a text box with
    - Name of the device
    - Device number for ERP software
    - Flow sheet drawing number
    - Elevation marking
  - If possible, mark only "sizing unit", and not all corresponding components that use compressed air in "sizing unit". Further information on devices can be found with flow sheet drawing number.

- Pipes
  - Differentiated major and connected pipes
  - Mark pipe size and flow medium
  - Do not show hose connections
- Equipments, fittings and valves
  - Do not show quick release couplings or other equipments that are not a crucial part of the process
  - Show only valves in major pipeline and valves before devices
  - Show strainers and reducers

4.2 P&I Diagram

P&ID was drawn with Autodesk Plant3D and it was based on layout based piping drawing. Building walls were drawn first, close to actual scale, using dashed grey line that can easily be differentiated from lines used to draw pipes. Major pipeline was drawn second with a thicker line weight to make next phase easier. Device text boxes were placed third to a place where the device approximately is. After the placement, all text boxes were cross checked alongside the flow sheets to make sure all needed devices are shown. Connecting pipelines were drawn fourth with a lighter lineweight. Connecting pipes are not in actual scale and are only used to show connections from the major pipeline to devices. Equipment, fittings and valves were placed last. Drawing symbols with explanations can be found in the appendix 4.



Picture 23. Piping and instrumentation diagram

Unfortunately, two devices in FB 5 were not identified. These devices are marked with a red box. Full size P&ID can be found in the appendix 5.

5 INSPECTION FINDINGS, ANALYSIS AND DEVELOPMENT SUGGESTIONS

During the inspection phase, several matters appeared that need to be addressed. This chapter compiles the final results of the inspection and covers arisen matters from three viewpoints. First, problematic structural piping solutions are covered. Second, the piping network is analyzed, based on research in chapter 2.2. And third, further development ideas are presented.

5.1 Problematic structural solutions

Problematic issues and solutions made in the piping are presented in this chapter with pictures and small description.

Picture 24. Major pipeline connection and valve in CB 11 spinner floor

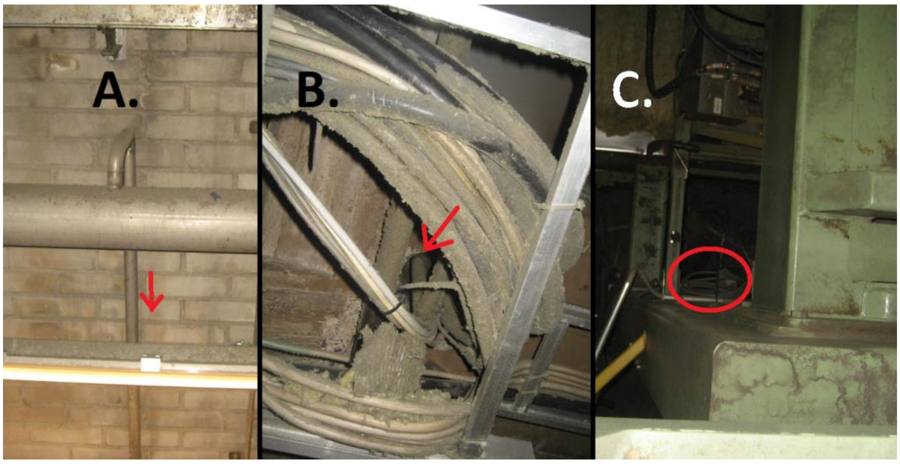
As seen in Picture 24, there is a T-connection close to a white wall in the major pipeline in CB 11 spinner floor. Operating this DN 150 ball valve is quite difficult because of the close proximity of the maintenance room (white wall) and hard accessibility to the valve hand operated lever, which cannot be seen in Picture 24, because it is above the piping.

Picture 25. Cut pipes under curing area in cellar floor

In Picture 25, two pipes have been cut, and pressure is held only by ball valves. End caps should be added to ensure no possible leaks occur.

Picture 26. Pipe and cables through the same hole

It is unclear if the hole in the concrete between cellar and machine floor was first made for the pipe, or for the cables. Nevertheless, this installation method is not advised and is potentially dangerous, as seen in Picture 26.



Picture 27. PAL 11 longitudinal saw piping

Pipe connection for longitudinal saw starts from major pipeline (Picture 27, A.) in machine floor, goes down to cellar floor and comes back up again from behind of longitudinal saw's control panel (Picture 27, C.). This pipe is very difficult to find due to poor lighting and accessibility to it in the cellar floor. Maintenance to this connection is very problematic because of accessibility and because it is almost hidden under cables and other items (Picture 27, B.). This pipe should be properly marked or rerouted in a different way to make it easier to find and maintain.

Picture 28. Dust filter unit pipes

Dust filter units for PAL 5 and 11 are both located outside of the factory. Currently incoming pipes for both dust filter units are not insulated. This might create condensation problems especially in winter, as piping to the filters come from approximately +25 °C processing area to ambient air temperature outside. Condensation is currently filtered with Festo filter/pressure reducer. Incoming pipes are shown next to red air flow direction arrows in Picture 28.

Picture 29. Unconventional reducer in major pipeline in PAL 11 packing

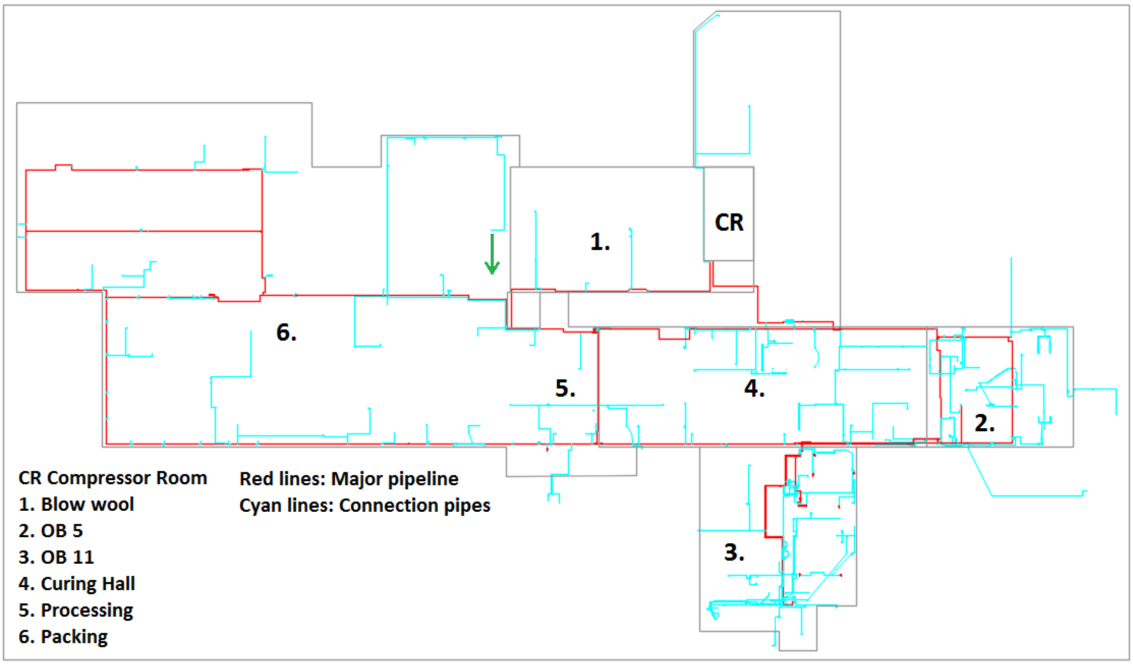
Packing area had a large building extension in 2000, and major pipeline was extended at the same time. In Picture 29, DN 150 pipe is part of the extended pipeline and DN 50 pipe is part of an older piping. It is unclear why new and old pipes were connected this way. If pressure gauges in devices that are connected to major pipeline after this unconventional reducer can be trusted, no significant pressure drop can be seen.

Picture 30. Leaking pipe end cap

In Picture 30, a pipe has been cut and an unconventional pipe cap added. The underside of the end cap is wet and oily, which indicates that some condensation has been gathering here and there must be a small leaking hole. The leak should be fixed and some form of a drain should be added to drain this pipe end.

5.2 Piping network analysis

The piping network is analyzed in this chapter, first area by area, and general remarks of all areas are at the end of the chapter.



Picture 31. Piping in entirety of every floor

Every pipe in every floor of the factory has been combined in Picture 31, to show the piping as a whole. This picture was made to present the complexity of the piping in some areas and to show the route of major pipeline. Larger version in appendix 6.

Areas CR and 1 are part of a loop, and every part was quite well visible and organized.

Area 2 was part of the major network loop, and a distribution loop was used to deliver the air needed within CB 11. Pipes were overall fairly easily found with a few exceptions, when piping solutions seemed to be made for some purpose that was no longer in use.

Area 3 is a single exception in regards of loop design, as it was made somewhere between linear and octopus network (refer to chapter 2.2). Every device connection had its own distribution pipe, and overall finding routes to distribution point was very confusing. There would have been space to make a loop inside FB 5, and the whole design seems that it was made in a hurry, without understanding how other parts of the network were designed.

In cupola and furnace buildings, there were seemingly arbitrary piping solution from floor to floor that with proper rerouting could be made more organized and efficient. Especially FB 5 network at its current form is vulnerable to leaks and possible maintenance problems because air flows in from only one direction. An evaluation project should be considered, where a looping design would be evaluated in terms of investment versus maintenance and energy efficiency.

In **area 4**, major pipeline travels in cellar and machine floors and is part of a larger loop. Finding pipes in this area was difficult due to lack of pipe marking and hard accessibility to major network, because of safety gates and excess amount of dust in some places.

In **areas 5 and 6**, the loop design was performed well. There is one linear pipe connection in packing area that does not close in a loop. The green arrow in area 6 shows the direction where this pipe could quite easily be connected. Some of the pipes are hard to locate, because some areas are behind a safety fence or some pipes were unreachable in a tight spot. However, overall major and connecting pipes were easier to locate in these, because they were clearly cleaner than other areas.

There were no condensate drains in packing area. Although all devices have a Festo filter before a hose connection, it would be most advisable to check if pipes are declining e.g. towards corners of an area, and add condensate drain to a most beneficial spot or spots.

All areas

The current network seems to be have been built with an assumption that it is condensate free, and the construction relies mostly on condensation removal in the compressor room. Gooseneck connections are quite rare, and an alarming number of pipes have been connected from below the major line (refer to Picture 9). No standard practice has been used throughout the factory, when it comes to connecting pipes to major network, and pipes seem to be connected in a manner, which has been seen easiest for each connection.

Piping material was not inspected in detail in this thesis. The most common piping material used is stainless steel, but some connections are made with common structural steel or plastic pipe. Plastic hoses used after filter/regulator units were translucent, white, gray, blue or black in different areas of the factory, especially in processing and packing areas, which caused problems with finding right connecting points. From the perspective of maintenance, this is quite problematic.

95 % of the network has been built by welding. Some connections are made with flanges and threaded connections. If the network has been built properly and no condensation occurs, a stainless steel welded network can be seen as a maintenance free network. The problem with a welded network is that it is also more expensive to reroute and expand this type of network.

In the best possible scenario, areas would be divided into smaller manageable areas with more loops. This would make it easier to close down some areas while there is no ongoing production. Currently, there are not many valves in the major line, and some of the valves are in a place, where it is hard to reach. With intelligent placement of valves that could opened and closed from the control room and well placed connecting loops, closing down areas would be significantly easier.

5.3 Development suggestions

Some development ideas arose during the inspection process. These ideas are simplified and presented in this chapter in order of importance, where the first subchapter is more important than the last.

5.3.1 Leaks

Every source material and website used in this thesis states that preventing and stopping leaks can provide the highest saving in a compressed air system. This is because compressed air, depending on how it is measured, has 2−5 % operating efficiency. With this efficiency ratio, part of the produced compressed air should not be wasted in leaks. Most commonly, leaks occur in poorly maintained filter/regulator units, valves, couplings, or torn hoses. In some cases, corroded pipes or poor welding might result to leaks. Usually, repairing leak points is very cheap compared to energy loss. On a weekly level, energy loss might not seem all that bad, but on an annual scale, the cost can be significant.

5.3.2 Measuring air consumption

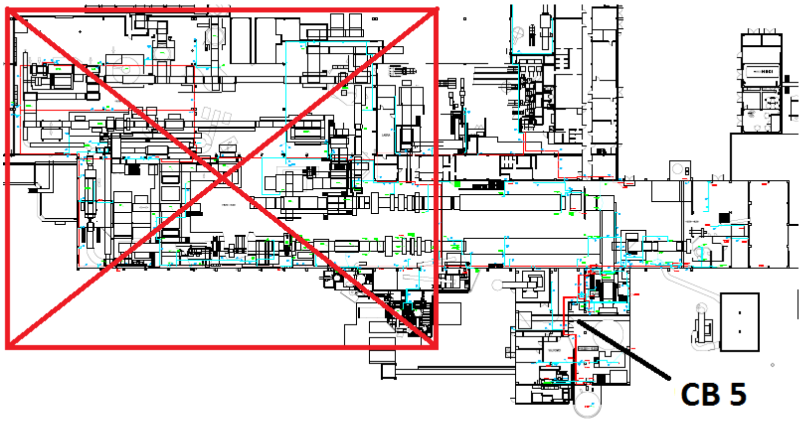
Air consumption is measured currently in compressor room, but not in any other location in the factory. Outgoing total air consumption is measured with Kaeser Sigma Air Manager 4.0. in the compressor room. Currently, there is no data on where and for what purpose highest air consumption is used for. To further understand and identify how much air is consumed in different areas of the factory, measuring devices should be added to the pipeline close to areas or devices that are suspected of high air consumption and/or to pipeline in certain intervals. This data could be further analyzed to indicate actual need of pressure or consumption in an area, device or device group. It is highly recommended that best measuring points are identified, and planning of air consumption measuring is started.

5.3.3 Lowering total air consumption during production standstill

During a production standstill, it would be very advisable to shut down parts of the main pipeline to control costs that come out of leaks. Ideas presented below can be put to practice relatively simply and should be considered for testing as soon as possible.

FB 5 continuous compressed air need

PAL 5 EMF is kept running during a standstill. There are certain devices that should be usable at all times, so airflow should also be available. These devices are not often used and do not require a large volume of compressed air to function. It would definitely be more energy efficient to find a solution where FB 5 air compressed air need is ensured and rest or most of the network is closed or shut down.



Picture 32. CB 5 solution one

One way to solve this would be to close valves in the main pipeline next to processing, so that only areas that are not inside the red box in Picture 32 would have air distribution, including CB 5. This method could quite easily be tested and it requires no pre-planning.

A second solution would be to shut down the compressor and close valves from main pipeline to CB 5 and connect the 2 m3 pressure vessel located in CB 5 cellar floor to CB 5 pipeline. This solution requires planning and new piping to be installed, but it could be a more long term and energy efficient solution.

Maintenance workshop

The maintenance workshop in cellar floor is located in the furthest corner of the factory. Compressed air to the workshop is being provided from major pipeline located in that area, and air needs to travel roughly 130 pipe meters from the compressor room to reach the workshop. The maintenance workshop has a very small or almost non-existing air consumption.during production standstill weekends. If compressed air is needed during said weekends, the most cost effective way would be to install a backup compressor to the workshop, so there would be no need to fill the pipeline for possible air consumption.

5.3.4 Marking

Pipe marking

Some pipes are marked with blue tape or with blue spray paint, but there is a considerable number of pipes that are not currently marked in any way. Additionally, flow direction, line number, flow medium and pipe nominal size could be marked in the same tape.

Picture 33. Marked pipe with loose tape

Some of the currently unmarked pipes could have been marked previously, but for some reason, the adhesive has failed (as seen in Picture 33) and some tapes have fallen off. To prevent this, tapes should be secured with another tape that goes around the pipe or spray painted with a stencil.

Pilar marking

During the inspection phase of this thesis, it became very clear that finding out the exact location, where one stands was quite difficult. It can be assumed that external contractors and new employees face a similar navigation problem within the factory. To counter this problem, support beams of the factory should be marked with the corresponding number used in the factory layout in all major floors. Premade number stencils and spray paint or premade number stickers would be a fast and cost effective way to solve this problem. As can be seen from Picture 33, using a sticker or a tape has some disadvantages. The size of the numbers should be no less than A4 paper size.

6 CONCLUSION

Before this thesis, the level of the compressed air network documentation for the Parainen unit was incomplete and in a poor condition. In some ways, old drawings were useful, but because of contradictory information, the drawings could not be trusted. Maintenance, planning and design connected to the network were difficult, and a need to clarify and compile all documentation was apparent. New drawings had to be done from beginning to end to solve this problem. This outset presented a great opportunity to look critically at the piping system from an outsider's viewpoint.

The actual inspection and drawing process was challenging and the most time consuming part of this thesis. All inspected areas were different. A considerable amount of dust, lack of easy access, ambient temperature and/or noise, low lighting and hidden or obscured piping solutions were basic challenges in different areas. Despite these challenges, new drawing were successfully made.

New layout based piping drawings offer information on actual pipe location and expand overall knowledge of the structure of current network. P&ID shows the network and distribution points in a more simplified manner and connects with process flow sheets. When more detailed P&ID is needed, this version will either be updated or used as a base document. Both drawing types in conjunction will be used on more accurate maintenance description and planning, occupational health and safety (OHS) development, future project planning and piping network development.

From this point on, when an extension or changes are made to the piping, new revisions of the current piping drawings should be made with clear marking of which are new pipes. If external companies or contractors are used in design process, Paroc drawing styles and templates should be used to keep documentation unified.

Several development areas and unconventional piping solutions were identified during the inspection and network analysis. Chapter 5 addresses these findings and shows that there are many areas that have to be further developed. Piping materials, support brackets and proper condensation draining in piping were not inspected in detail, and an inspection of those should be carried out at some point, as well. Also starting a PATE-analysis (Motiva 2015) should be considered.

At this point, a leak detection device has been acquired, some leak points have been identified, future compressor and air dryer investments are planned and total air consumption is being monitored on a monthly level with SAM 4.0 and consumption data is analyzed. These actions indicate that development is taken seriously in Paroc with an aim of making compressed air distribution safe and energy efficient.

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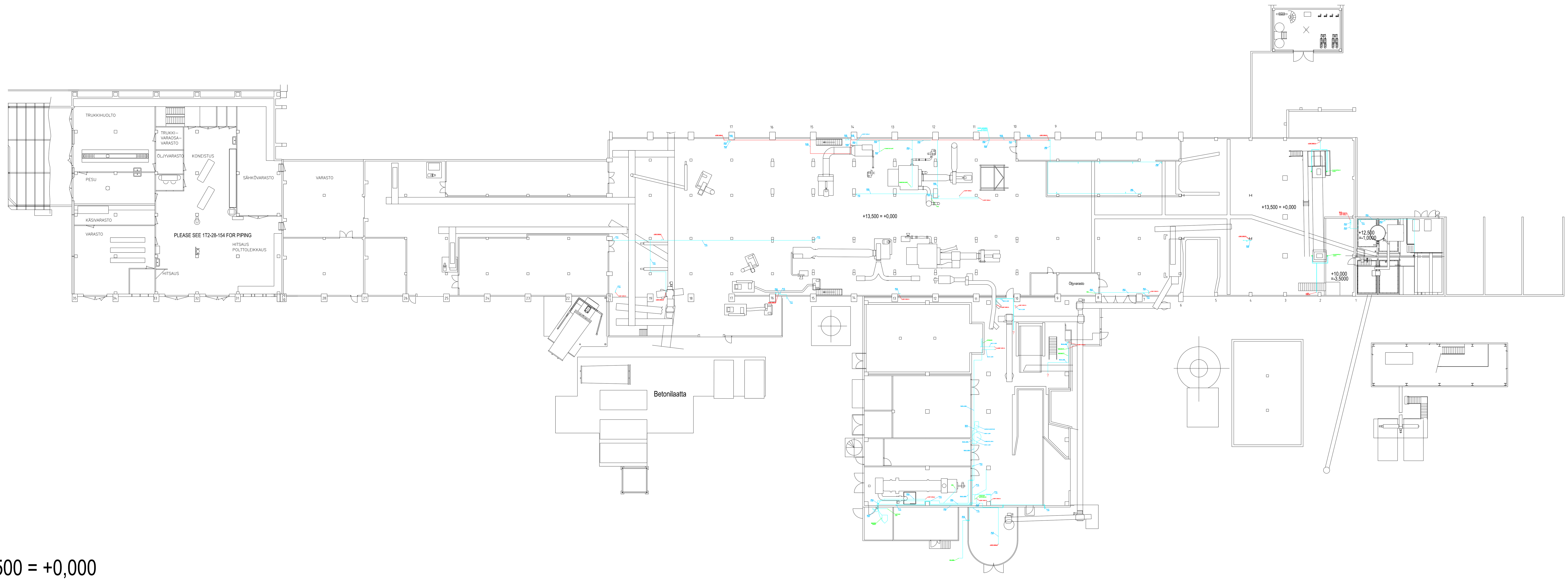
Topring: Compressed air distribution system (open) [online]. Available: http://www.topring.com/images/PDF/TOPRING_designing_compressed_air_distribution_network_EN.pdf (2 November 2016)

PRELIMINARY



+13,500 = +0,000

Part	Description	Doc. no/Std/Supplier	Dimension	Material	Weight/pcs	Pcs

General tolerances ISO 2768-mk & ISO 13920-AE | Surface roughness SFS-EN ISO 4287:en | Surface treatment acc. to painting program for metals Standard ISO 12944

Scale	Total weight	Made by	Date	Appr. by	Date
1:250	kg	jamyl	22.12.2016		

PAROC

PARGAS
FACILITIES SERVICES
COMPRESSED AIR

ERP No

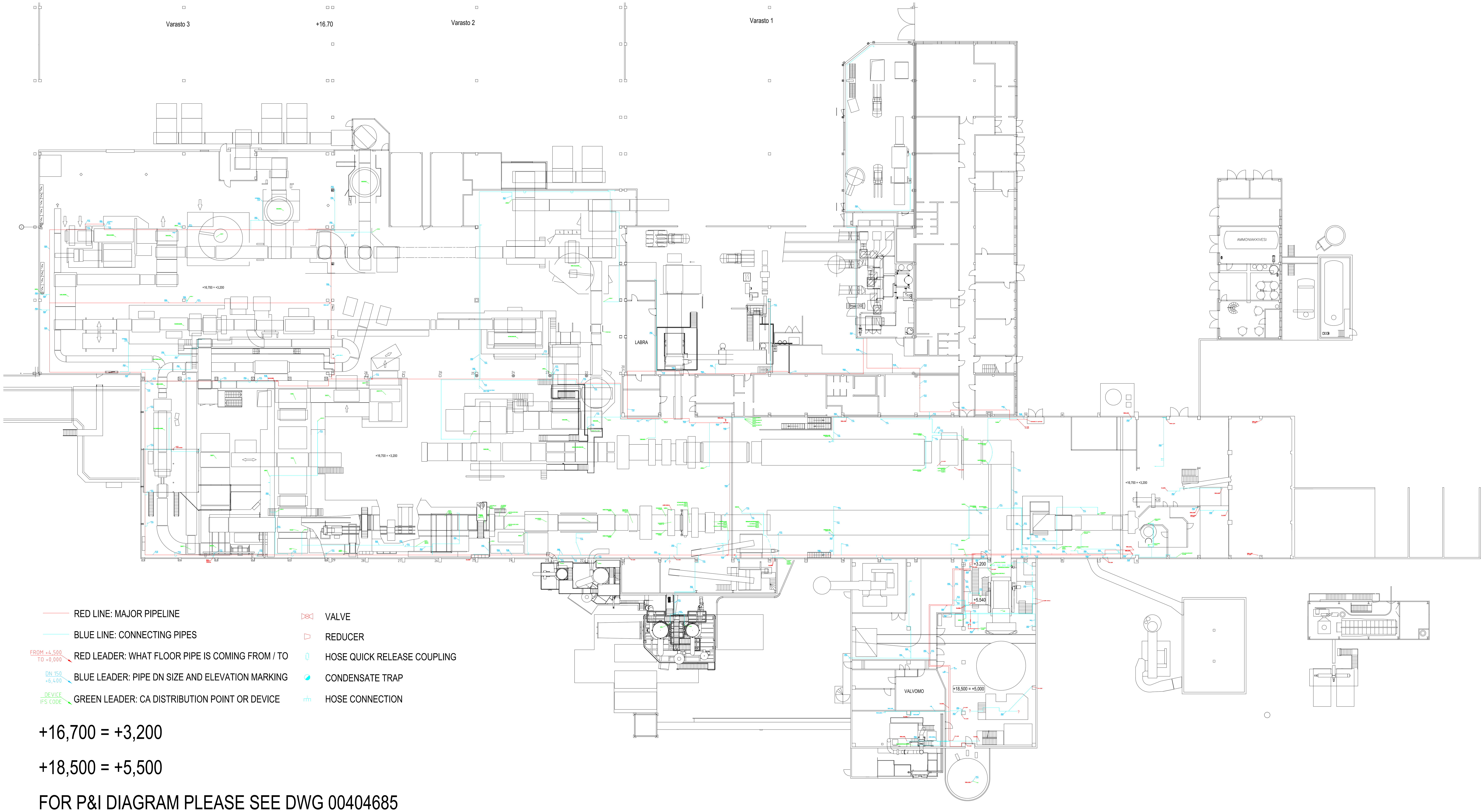
Size	Drwg.No	Rev.
	00406142	

Belongs to

ALL FLOORS
WHOLE FACTORY COMPRESSED AIR PIPING

Mark	Change	Date	Made by

PRELIMINARY



RED LINE: MAJOR PIPELINE

BLUE LINE: CONNECTING PIPES

FROM +4,500 TO +0,000 — RED LEADER: WHAT FLOOR PIPE IS COMING FROM / TO

DN 150 +5,400 — BLUE LEADER: PIPE DN SIZE AND ELEVATION MARKING

DEVICE IFS CODE — GREEN LEADER: CA DISTRIBUTION POINT OR DEVICE

VALVE

REDUCER

HOSE QUICK RELEASE COUPLING

CONDENSATE TRAP

HOSE CONNECTION

+16,700 = +3,200

+18,500 = +5,500

FOR P&I DIAGRAM PLEASE SEE DWG 00404685

Mark	Change	Date	Made by

Part	Description	Doc. no/Std/Supplier	Dimension	Material	Weight/pcs	Pcs

General tolerances ISO 2768-mk & ISO 13920-AE | Surface roughness SFS-EN ISO 4287:en | Surface treatment acc. to painting program for metals Standard ISO 12944

Scale 1:250 | Total weight kg | Made by jamyl | Date 22.12.2016 | Appr. by | Date

PAROC

PARGAS
FACILITIES SERVICES
COMPRESSED AIR

ERP No

Size | Drwg.No 00406142 | Rev.

Belongs to

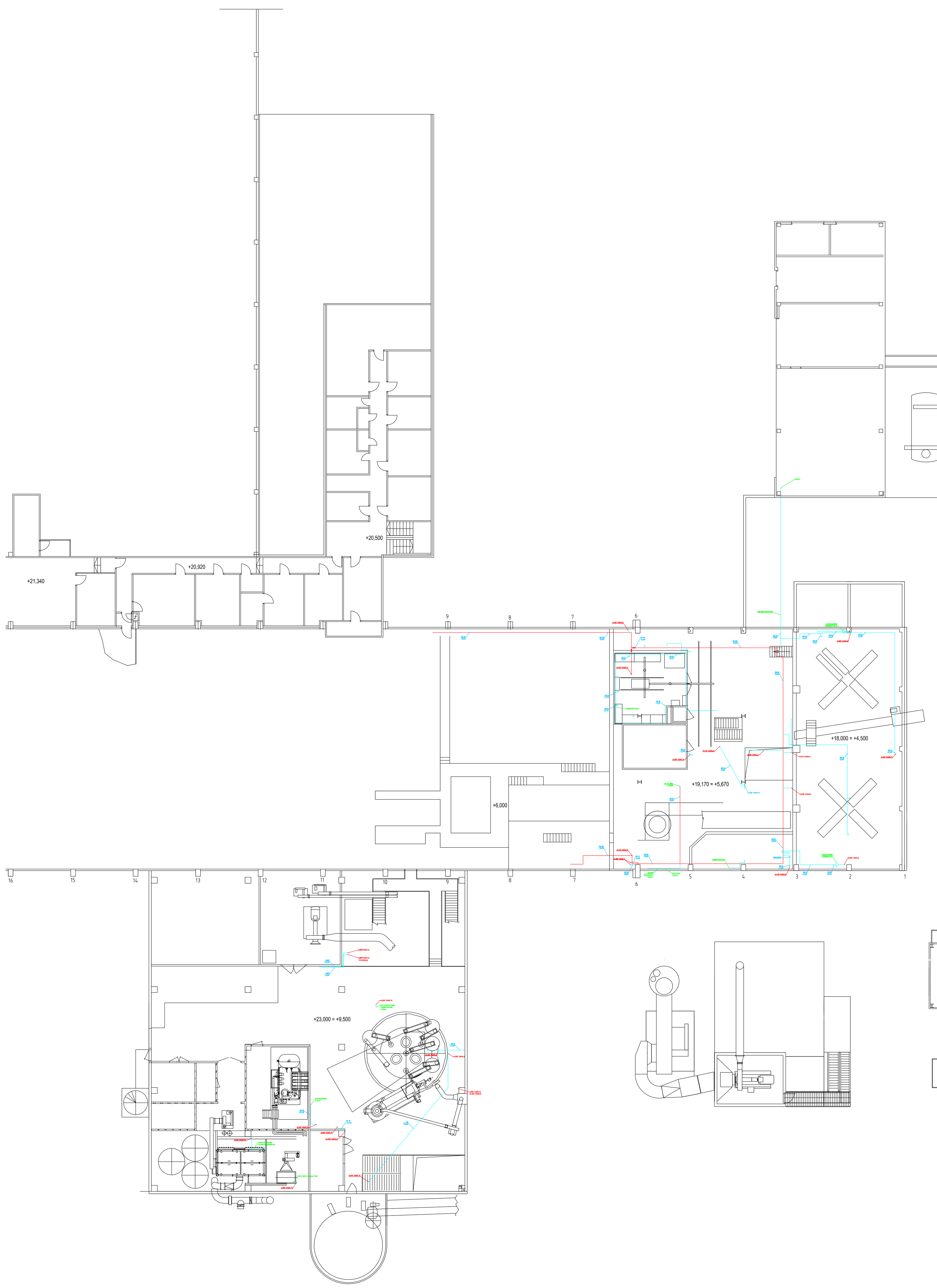
ALL FLOORS
WHOLE FACTORY COMPRESSED AIR PIPING

PRELIMINARY

+18,000 = +4,500

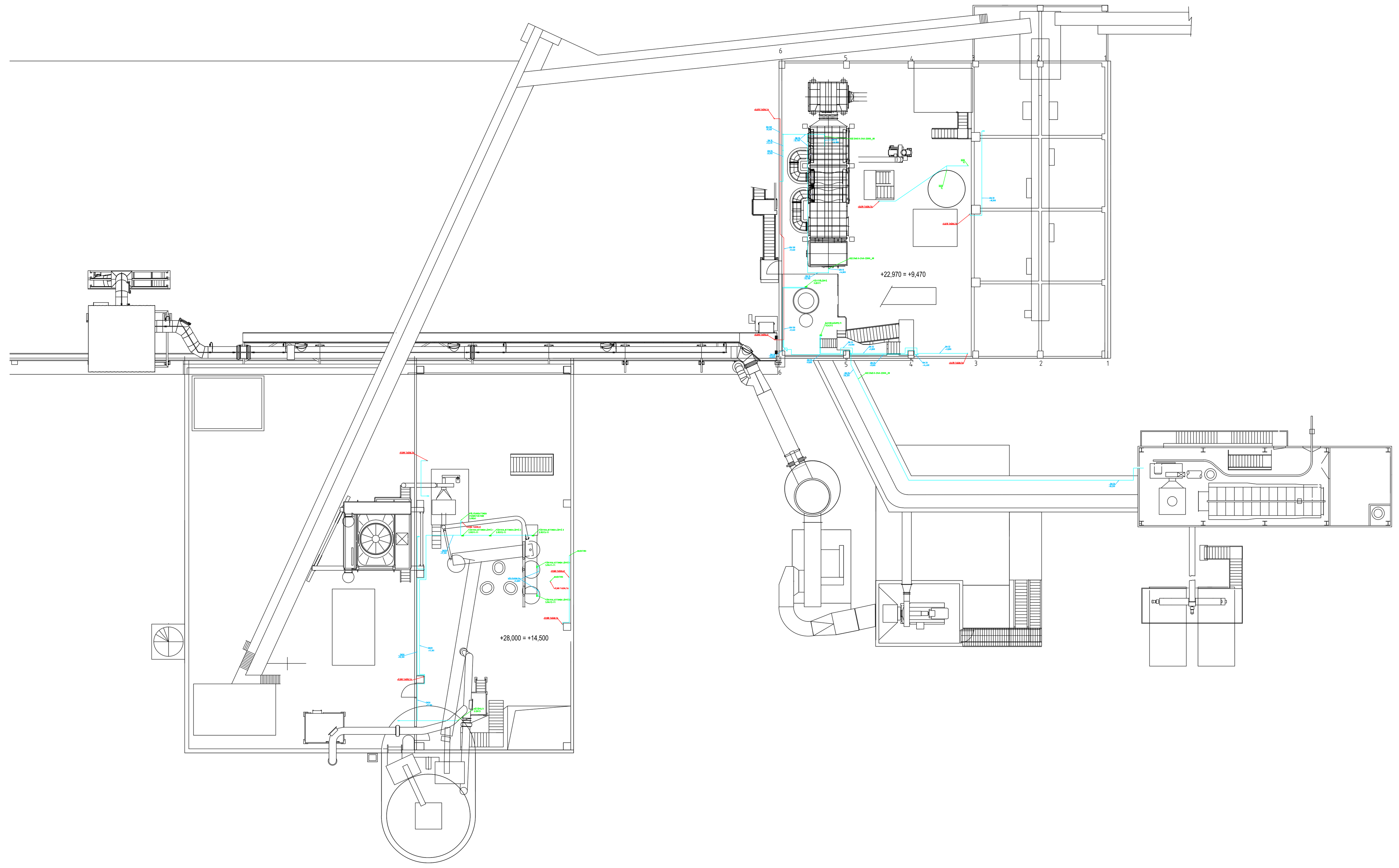
+19,170 = +5,670

+23,000 = +9,500



+22,970 = +9,470

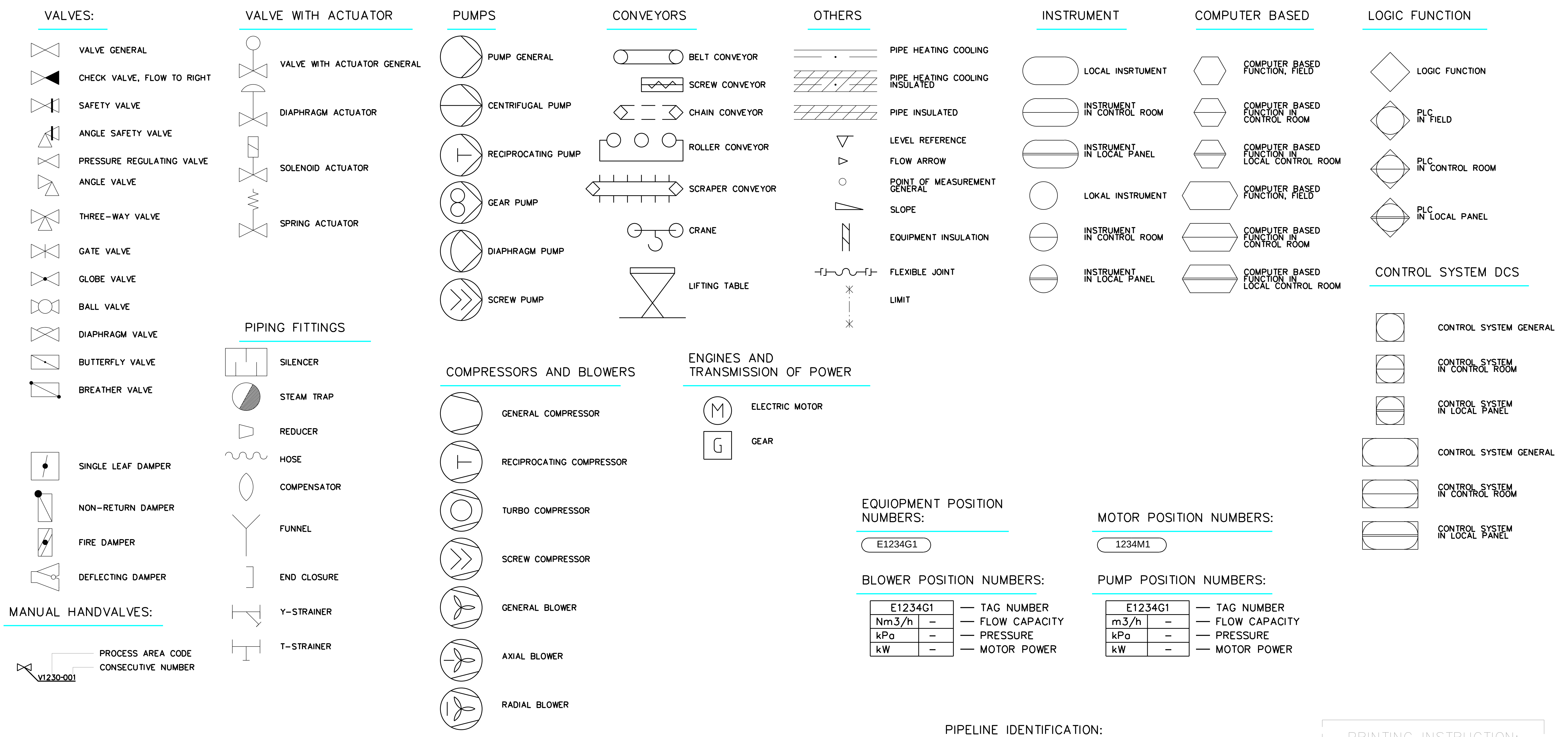
+28,000 = +14,500



Part	Description	Doc. no/Std/Supplier	Dimension	Material	Weight/pcs	Pcs

General tolerances ISO 2768-mk & ISO 13920-AE		Surface roughness SFS-EN ISO 4287:en	Surface treatment acc. to painting program for metals Standard ISO 12944		
Scale 1:250	Total weight kg	Made by jamyl	Date 22.12.2016	Appr. by	Date
PAROC	PARGAS			ERP No	
	FACILITIES SERVICES			Size	Drwg.No 00406142 / Rev.
	COMPRESSED AIR				
Belongs to	ALL FLOORS				
	WHOLE FACTORY COMPRESSED AIR PIPING				

Mark	Change	Date	Made by



CODES FOR FLOW SUBSTANCES:

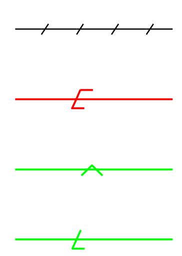
PSK STANDARDS ASSOCIATION, PSK 0901, 4. EDITION

ACP	COMPRESSED AIR
FNG	NATURAL GAS
QAM	LIQUID AMMONIA
QSI	SILANE
WDE	DEMINERALIZED (SOFT) WATER
WCL	COOLING WATER
WPW	PROCESS WATER
WTW	TECHNICAL WATER
WWS	WASH (FLUSHING) WATER
WRA	RAW WATER
ODU	DUST OIL
OLU	LUBRICATING OIL
LRG	ROSIN SIZE (RESIN)
LBI	BINDER

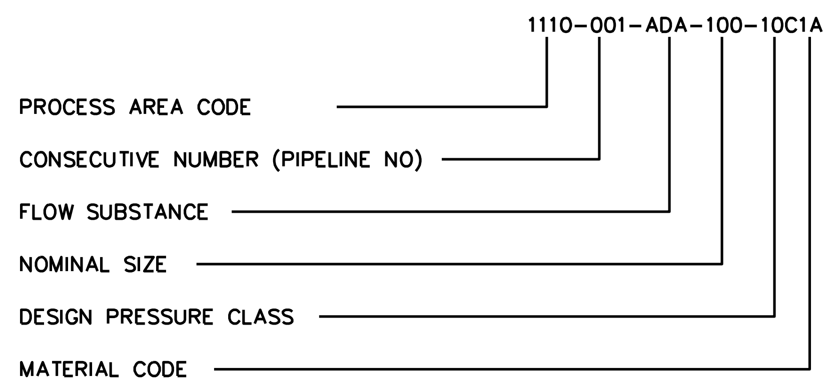
MATERIAL CODES

A	CAST IRONS
A1	GREY CAST IRON
A2	SPHEROIDAL GRAPHITE CAST IRON
C	STEEL FOR ELEVATED TEMPERATURES
C1	NON ALLOY STEELS FOR ELEVATED TEMPERATURES
C2	Mo-ALLOYED STEEL
G	EXTERNALLY COATED STEELS
H	STAINLESS STEEL
H1	AUSTENITIC STAINLESS CrNi-STEEL
H2	AUSTENITIC STAINLESS CrNiMo-STEEL
H3	AUSTENITIC-FERRITIC STAINLESS STEEL

INSTRUMENT LINES



PIPELINE IDENTIFICATION:



PRINTING INSTRUCTION:

OBJECT COLOR	LINEWEIGHT	COLOR
1 RED	0.18	7
2 YELLOW	0.25	7
3 GREEN	0.35	7
4 CYAN	0.40	7
5 BLUE	0.25	7
6 MAGENTA	0.13	7
7 WHITE	0.35	7
8 GREY	0.10	7

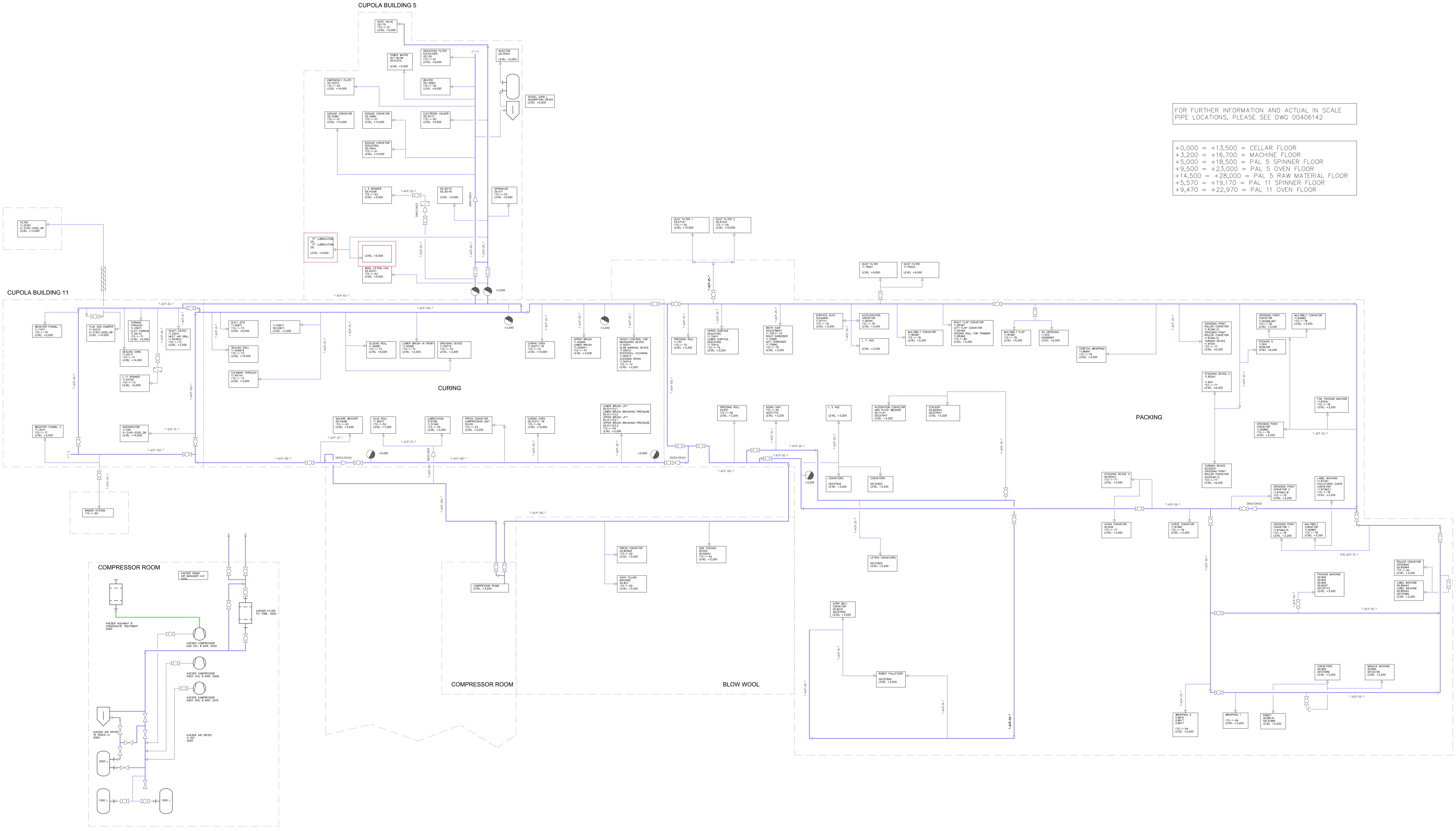
SETTINGS:

SNAP = 2.5
DIMSCALE = 1
LTSCALE = 1
PAPER SIZE = A2
SCALE 1:1

Mark	Change	Made by

General tolerances ISO 2768-mk & ISO 13920-AE	Surface roughness SFS-EN ISO 4287:en	Surface treatment acc. to painting program for metals Standard ISO 12944	
Scale	Total weight kg	Made by hakna	Date 30.6.2014	Appr. by	Date
PAROC	GENERAL DOCUMENT	ERP No	
		Size A2	Drwg.No 00327653	Rev.
Belongs to	FLOW SHEET SYMBOLS		

PRELIMINARY



FOR FURTHER INFORMATION AND ACTUAL IN SCALE PIPE LOCATIONS, PLEASE SEE DWG 00406142

+0,000 = +13,500 = CELLAR FLOOR
+3,200 = +16,700 = MACHINE FLOOR
+5,000 = +18,500 = PAL 5 SPINNER FLOOR
+9,500 = +23,000 = PAL 5 OVEN FLOOR
+14,500 = +28,000 = PAL 5 RAW MATERIAL FLOOR
+5,570 = +19,170 = PAL 11 SPINNER FLOOR
+9,470 = +22,970 = PAL 11 OVEN FLOOR

General tolerances ISO 2768-mk & ISO 13920-AE		Surface roughness SFS-EN ISO 4287:en	Surface treatment acc. to painting program for metals Standard ISO 12944	
Scale	Total weight kg	Made by jamyl	Date 2.12.2016	Appr. by / Date
PAROC	PARGAS COMMON		ERP No	
	PACO PLANT 3D PROJECT		Size / Drwg.No 00404685 / Rev.	
Belongs to	COMMODITY DISTRIBUTION			
	COMPRESSED AIR			

Date | Made by