ANEXOS

ANEXO I Principales hitos en la historia de Knorr-Bremse

Year	Milestones/Events
1905	Georg Knorr founds Knorr-Bremse GmbH in Berlin
1910 -1924	Knorr Bremse develops air brakes for freight trains and becomes a major European manufacturer of rail vehicle brakes
1922	Development of air brakes for commercial vehicles commences
1931-1939	The Hildebrand-Knorr (HiK) braking system used for express trains in 17 countries. 90% of all German trucks in the 7-16 t range are fitted with Knorr braking systems
1945	The Knorr-Bremse plant in Berlin is confiscated and dismantled at the end of the 2nd Wold War
1945-1953	Development and manufacture of braking systems begins again in the western part of Germany, with the main emphasis on the HiK system. Company headquarters are relocated to Munich
1960 - 1980	Knorr-Bremse plays a leading role in the development of braking technology for rail and commercial vehicles. Knorr-Bremse establishes the new UIC standard with its KE control valve
1985-1993	During a difficult phase in the company´s development, Heinz Hermann Thiele acquieres a majority share in Knorr-Bremse (previously held by Dr.Jens von Bandemer) and launches a radical restructuring program. The AAR DB60 control valve gains Knorr-Bremse access to the North American market. Thiele initiated make Knorr-Bremse the world´s leading manufacturer of braking systems in Rail Vehicle and Commercial Vehicle
1996	Series production of pneumatic disc brakes for commercial vehicles begins
1999	Robert Bosch GmbH merges its activities in the electronic brake control sector with Knorr-Bremse Commercial Vehicle Systems. Knorr-Bremse takes a 60% share, giving it overall managerial control of the joint venture; Bosch retains a 20% share.
2002	Knorr-Bremse takes over Honeywell International Inc., USA its share of joint ventures in Europe, Brazil and the USA. Bendix Commercial Vehicle Systems becomes a subsidiary of Knorr-Bremse AG. The Knorr-Bremse Group achieves sales of EUR 2.1 billion for the first time.
2005	The Knorr-Bremse Group celebrates its centenary
2009	In fiscal 2009 the Knorr-Bremse Group posted sales of EUR 2.76 billion and employed 14,432 people. The company celebrated the 150th anniversary of the birth of its founder Georg Knorr
2010	In fiscal 2009 the Knorr-Bremse Group posted sales of EUR 3.712 billion and employed 16.277 people.

Tabla 2 Principales hitos en la historia de Knorr-Bremse

ANEXO II. Participación Consolidada de Knorr-Bremse en empresas afiliadas

CONSOLIDATED AFFILIATED COMPANIES	Share in capital (%)
Albatros GmbH, Munich/Germany	100
Anchor Brake Shoe Company LLC, West Chicago/USA	100
BCVS Canadian Holdings LLC, Anjou , Quebec/Canada	100
BCVS Mexican Holdings LLC, Cd Acuña, Coach/Mexico	100
Bendix Commercial Vehicle Systems LLC, Elyria, Ohio/USA	100
Bendix CVS Canada Inc., Anjou, Quebec/Canada	100
Bendix CVS de Mexico SA de CV, Cd Acuña, Coah/Mexico	100
Bendix Spicer Foundation Brake Canada, Inc., Kingston, Ontario/Canada	100
Bendix Spicer Foundation Brake LLC, Elyria, Ohio/USA	80
Bost Ibérica S.L., Madrid/Spain	100
BSFB Holdings, Inc., Elyria, Ohio/USA	100
Di-Pro, Inc., Fresno, California/USA	100
Dr.techn. Josef Zelisko Ges.m.b.H., Mödling/Austria	100
EMC Traction S.r.l., Milan/Italy	100
Freinrail Systèmes Ferroviaires S.A., Reims/France	100
Frensistemi S.r.l., Florence/Italy	100
Hasse & Wrede CVS Dalian, China Ltd., Dalian/China	70
Hasse & Wrede GmbH, Berlin/Germany	100
Hasse & Wrede North America Inc., North Aurora, IL/USA	100
IFE CR a.s., Brno/Czech Republic	100
IFE North America LLC, Westminster, Md./USA	100
IFE - Tebel Australia Pty. Ltd., Granville / Australia	100
IFE - Tebel Technologies B.V., Leeuwarden/The Netherlands	100
IFE Victall Railway Vehicle Door Systems (Qingdao) Co. Ltd., Qingdao/China	59
IGE - CZ s.r.o., Brno / Czech Republic	100
Indústria Freios Knorr Ltda., São Paulo / Brazil	100
KB Delta Beteiligungs GmbH, Munich/Germany	100
KB Gamma Beteiligungs GmbH, Munich/Germany	100
KB Lambda Beteiligungs GmbH, Munich/Germany	100
KB Media GmbH Marketing und Werbung, Munich/Germany	100
KB Sigma Beteiligungs GmbH, Munich/Germany	100
KB Omikron Beteiligungs GmbH, Munich/Germany	100
Knorr Brake Corporation, Westminster, Md./USA	100
Knorr Brake Holding Corporation, Watertown, NY/USA	89.3
Knorr Brake Ltd., Kingston, Ontario/Canada	100
Knorr Brake Truck Systems Company, Watertown, NY/USA	100
Knorr.Bremse Asia Pacific (Holding) Ltd., Hong Kong	100
Knorr-Bremse / Nankou Ais Supply Unit (Beijing) Co., Ltd., Nankou/China	55
Knorr-Bremse Australia Pty. Ltd., Granville/Australia	100
Knorr-Bremse Benelux B.V.B.A., Heist-op-den-Berg/Belgium	100
Knorr-Bremse Beteiligungsgesellschaft mbH, Munich/Germany	100
Knorr-Bremse Brake Equipment (Shanghai) Co., Ltd., Shanghai/China	100
Knorr-Bremse Braking Systems for Commercial Vehicles (Dalian) Co., Ltd., Dalian/China	100
Knorr-Bremse CARS LD Vehicle Brake Disc Manufacturing (Beijing) Co. Ltd., Daxing/China	50
Knorr-Bremse Commercial Vehicle Systems Japan Ltd., Tokyo/Japan	80
Knorr-Bremse Fékrendszerek Kft., Kecskemét/Hungary	100
Knorr-Bremse Ges.m.b.H., Mödling/Austria	100

Knorr-Bremse India Pvt. Ltd., Faridabad/India	100
Knorr-Bremse Investment GmbH, Munich/Germany	100
Knorr-Bremse KAMA Systems for Commercial Vehicles OOO, Naberezhnye Chelny/Russia	50
Knorr-Bremse Nordic Rail Services AB, Lund/Sweden	75
Knorr-Bremse Polska SfN Sp.zo.o., Warsaw/Poland	100
Knorr-Bremse Rail Systems Japan Ltd., Tokyo/Japan	94
Knorr-Bremse Rail Systems Korea Ltd., Seoul/South Korea	100
Knorr-Bremse Rail Systems OOO, Moskow/Russia	100
Knorr-Bremse Rail Systems (UK) Ltd., Melksham, Wiltshire/Great Britain	100
Knorr-Bremse S.A. (Pty) Ltd., Kempton Park/South Africa	75
Knorr-Bremse S.R.L., Bucharest/Romania	70
Knorr-Bremse Sistemas para Veículos Comerciais Brasil Ltda., São Paulo / Brazil	100
Knorr-Bremse Sistemas para Veículos Ferroviários Ltda., São Paulo / Brazil	100
Knorr-Bremse Sistemi per Autoveicoli Commerciali S.p.A., Arcore/Italy	100
Knorr-Bremse Systems för Tunga Fordon AB, Malmö/Sweden	100
Knorr-Bremse Systeme für Nutzfahrzeuge GmbH, Munich/Germany	80
Knorr-Bremse Systeme für Schienenfahrzeuge GmbH, Munich/Germany	100
Knorr-Bremse Systeme für Schienenfahrzeuge Ibero Holding GmbH, Munich/Germany	100
Knorr-Bremse Systèmes pour Véhicules Utilitaires France S.A., Lisieux/France	100
Knorr-Bremse Systems for Commercial Vehicles India Pvt. Ltd., Pune/India	74
Knorr-Bremse Systems for Commercial Vehicles OOO, Moscow/Russia	100
Knorr-Bremse Systems for Commercial Vehicles Ltd., Bristol/Great Britain	100
Knorr-Bremse Systems for Rail Vehicles (Suzhou) Co., Ltd., Suzhou/China	100
Knorr-Bremse Systemy dla Kolejowych Sroków Lokomocji PL Sp. Z.o.o., Cracow/Poland	100
Knorr-Bremse Systémy pro uzitková vozidla CR s.r.o., Hejnice/Czech Republic	100
Knorr-Bremse Ticari Arac Fren Sistemieri Limited Sirketi, Istanbul/Turkey	100
Knorr-Bremse US Investment GmbH, Munich/Germany	100
Knorr-Bremse US Beteiligungs GmbH, Munich/Germany	100
Knorr-Bremse Vasúti Jármü Rendszerek Hungária Kft., Budapest/Hungary	100
Knorr-Bremse Verwaltungsgesellschaft mbH, Munich/Germany	100
Maquiladora de Acuña SA de CV, Cd Acuña, Coah/Mexico	100
Merak Jinxin Air Conditioning Systems (Wuxi) Co., Ltd., Wuxi/China	51
Merak North America LLc, Albany/USA	100
Merak Railway Technologies (Shanghai) Co., Ltd., Shanghai/China	100
Merak Sistemas Integrados de Climatización SA., Getafe/Spain	100
Microelettrica Power Devices (Pty) Ltd., Johannesburg/South Africa	95
Microelettrica Power (Pty) Ltd., Johannesburg/South Africa	74
Microelettrica Scientifica (Pty) Ltd., Johannesburg/South Africa	100
Microelettrica Scientifica S.p.A., Rozzano/Italy	100
Microelettrica USA LLC, Randolph, New Jersey/USA	100
MicroEner S.A.S., Noisy le Grand/France	89.9
M.S. Resistances S.A.S., Saint Chamond /France	51
New York Air Brake Corporation, Watertown, NY/USA	100
Oerlikon-Knorr Eisenbahntechnik AG, Niederhasli/Switzerland	100
Officine de Zan S.R.L., Rozzano, Milan/Italy	100
Sigma Coachair Group (China) Co. Ltd, Changzhou/China	100
Sigma Coachair Group Pty. Ltd, Wetherill Park, Sydney/Australia	100
Sigma Coachair Group (US) Inc., Chicago/USA	100
Sigma Transit Systems Pty. Ltd., Wetherill Park, Sydney/Australia	100
Skach Ges.m.b.H., Mölding/Austria	100
Sociedad Española de Frenos, Calefacción y Señales S.A., Getafe/Spain	100
Stahlwerk Volmarstein GmbH, Wetter (Ruhr)/Germany	100

STE Schwingungs-Technik GmbH, Klieken/Germany	100
Sydac Pty. Ltd., Adelaide/Australia	100
Techtrain Associates Limited, Doncaster/Great Britain	80
Unicupler GmbH, Niederurnen/Switzerland	100
Westinghouse Brakes Australia Pty. Ltd., Granville/Australia	100
Westinghouse Platform Screen Doors Ltd., Walsall/Great Britain	100
Westinghouse Platform Screen Doors (Guangzhou) Ltd., Guangzhou/China	65

Tabla 3 Participación consolidada de Knorr-Bremse en empresas afiliadas

ASSOCIATED COMPANIES VALUED USING THE EQUITY METHOD	Share capital (%)
Gorilla Brake & Components, Inc., Brantford, Ontario/Canada	20
Webasto Kiekert GmbH, Karlsfeld/Germany	50

Tabla 4 Compañías asociadas usando método equitativo

AFFILIATED COMPANIES NOT INCLUDED IN CONSOLIDATION	Share Capital(%)
Black River Air Logistics Corp., Watertown, NY/USA	100
Freios Knorr Argentina S.A., Buenos Aires/Argentina	100
KB Investment UK Ltd., Chippenham/Great Britain	100
Knorr-Bremse RUS OOO, Nizhny Novgorod/Russia	100
Knorr-Bremse SA Holding Company (UK) Ltd., Melksham, Wiltshire/Great Britain	100
Metco Techincal Consulting AG, Zug/Switzerland	100

Tabla 5 Compañías afiliadas no incluidas en consolidación

ANEXO III. Portafolio de Knorr-Bremse para Vehículos Ferroviarios

Braking Systems

• Air supply	Compressors, air dryers, complete systems and accessories (pressure switches, condensate collector units, oil filters and safety valves)
• Bogie Equipment	Brake discs, brake pads, brake calliper units, block brake units, UIC brake cylinders and slack adjusters, track brakes and conventional or compact braking equipment
• Brake Control	Control units, carrier systems, control valves, driver´s cab equipment, ESRA (Electronic Systems for Rail Applications), diagnosis systems, operator test benches for maintenance and overhaul of compressors, bogie equipment, control device and components, hydraulic actuation.
• Hydraulics	Electro-Hydraulic units, braking pressure generator, hydraulic levelling and suspension systems
• Sanding Systems	Air supply, sanding unit, sand pipe heaters, sand level indicator, sand box and sand box cover

Door Systems

• Entrance Systems	Sliding plug for sliding door applications, connection between internal doors and fire protection doors, driver´s cabin doors and access doors, automatic ramps, microprocessors based door control systems, detection systems and service
• Platform Dorr Systems	It increases the passenger safety, the control of passenger flow and the effective protection on the environment.

Air Conditioning Technology

• Heating, Ventilation and Air Conditioning Systems	Conventional or heat pump systems, compact package or split systems, roof, passenger and drivers cab area, microprocessor based temperature control, air quality systems, fire and smoke detection systems, air duct systems (new and retrofitted vehicles)
• Electronic Applications	Passenger and drivers cab areas overpressure protection systems, auxiliary power supply units, emergency ventilation inverters, bench testers for HVAC units, transformers and speed regulators for motors

Derailment Detection

• Electronic systems	Both suitable for a wide variety of vehicle types like passenger cars, metros, urban trains, multiple units, dangerous goods transport, goods wagons and tank cars
• Pneumatic Applications	

Windscreen Wiper and Wash Systems

• Electric powered	They cover the whole spectrum of rail vehicles (tramway, metro, locomotive and high-speed trains)
• Pneumatic powered	

Control Components	
• Resistors	Rheostatic braking allows the vehicle´s kinetic energy to be dissipated electrically.
• Contactors	They are used to connect and disconnect high power traction converters, auxiliary converters, auxiliary circuits (heating, climate control, compression, magnetic brakes, lighting)
• Disconnectors	They are used in multi-system locomotives to change the configuration of the traction circuit when the catenary voltages changes
• Integrated Functional Units	to assemble different supplied contactors and disconnectors
• High Voltage Transducers	For railway traction applications
• DC High Speed Circuit Breakers	for the electrical circuit protection from failures

Tabla 6 Productos Knorr-Bremse para vehículos Ferroviarios

ANEXO IV. Portafolio de Knorr-Bremse para Vehículos Comerciales

Braking Systems

• Pneumatics	During braking, or in case of a change of load, compressed air is directed via control valves and/or control modules to the brake actuators or suspension bellows (at system pressures over 10 bar)
• Mechanics	The actual braking effect is achieved mechanically. Disc brakes manufactured by Knorr-Bremse weighing under 50 kg can at present apply a clamping force of 300 kN and produce a retardation of 900 kW
• Electronics	In modern braking, safety and suspension systems, electronic has in many areas replaced pneumatics
• Complex Control Engineering	The wide experience of Knorr-Bremse in the provision of complex pneumatic and control systems, provides good solutions for outside braking and suspension systems

Dampers

• Viscous-Dampers rotary oscillation dampers	Viscous-Dampers reduce rotary oscillation by the elastic and/or damping combination of secondary mass (gyrating ring) and primary mass (housing)
• Viscous-Dampers with decoupled pulley	Viscous-Dampers with decoupled pulley provides a compact solution for decoupling rotary oscillation between crankshaft and pulley while simultaneously reducing rotary oscillation in the crankshaft
• Hydraulic Dampers	The Hydrolastic damper reduces rotary oscillation in accordance with the hydrodynamic extrusion principle

Compressors

• Heating, Ventilation and Air Conditioning Systems	Compressors provide compressed air to all pneumatic braking systems. It is driven, as a rule, by the vehicle´s engine. Knorr-Bremse product portfolio covers a wide range of requirements in terms of transport and propulsion. The range includes flange mounted (with direct gear drive or base mounted), with belt drive, one or two cylinder compressors. They can also be supplied with our optional energy-saving-system (ESS). Oil emission reduction and saving in fuel costs are the result of Knorr-Bremse innovation

Air treatment

• Air Drying	Knorr-Bremse offers the tried and tested air drying cartridge. This preparation is necessary to protect the entire pneumatic system from freezing and internal corrosion (ensure is efficient operation and increase the overall life of the system)
• Oil Capture plus Air Drying (OSC)	This solution provides a solution for stripping oil in droplet and vapour form from the compressed air before the air is dried (in order to increase the life of the braking system)
• Conventional Air Treatment	Knorr-Bremse offers air-dryers, pressure regulators, circuit protection valves to pressure limiters that contribute to the functional safety of pneumatic systems. Also an extremely compact monobloc (called APU), which combines all the functions of an air preparation system in an single appliance, is developed by Knorr-Bremse
• Electronic Air Treatment (EAC)	This system combines the tried and tested pneumatics of decisive functions with electronic operations. It provides a reduction in the fuel consumption an well as increases safety and comfort

Electronic Systems	
• ABS,ASR	ABS prevents locking of the wheels when braking, while ASR (Traction Control System, TCS) ensures that, when accelerating. Knorr-Bremse provides these systems for all vehicles types and trailers with air braking
• EBS, CFC	EBS integrates the basic functions of ABS and ASR into one electronic system. It produces a shorter response time and braking distance. It integrates also the control of wear, downhill cruise control and Coupling Force Control (CFC). CFC system distributes optimal braking power between tractor vehicle and semi trailer. Knorr-Bremse offer both of them for all the vehicle types
• ESP	It causes automatic stabilization of the vehicle in critical driving situations. Knorr-Bremse is the first company in the world to offer an ESP system even for trailer combinations (articulated trains)
• ELC	Electronic Levelling Control (ELC) offers electronic level regulation, an axle lifting function for vehicles with pneumatic suspension
• ACC	Adaptive Cruise Control System maintains the correct distance from the vehicle in front
Valves	
• Valves portfolio	Knorr-Bremse product program covers all the requirement of a conventional braking system, for example foot brake valves, hand brake valves, relay valves, brake pressure regulators, trailer control valves, air suspension valves or selector valves for operating with containers
Disc Brakes	
• Disc Brakes offer	Knorr-Bremse has set the benchmarks for commercial vehicles with a total weight of from 6 to over 44 tonnes, with the pneumatic tensioned disc brake. Advantages are low weight, compact design, even brake pad wear, improved servicing convenience, cost savings and increased safety
Drum Brakes	
• S-Cam Brake	With the s-cam brake, the cam and camshaft are rotated as a result of the force of the brake actuator acting on the slack adjuster
• Slack Adjuster	Automatic Slack Adjusters compensate for the wear of brake linings and drum and ensure a constant running clearance between these parts
Actuators	
• Actuators offer	Knorr-Bremse has developed a modular brake cylinder concept which offers solutions for nearly all uses and thereby covers vehicles of different sizes and performance classes, and also different cylinder designs
Tools and Diagnostics	
• ECUtalk	ECUtalk is a PC based diagnosis program for Knorr-Bremse electronic braking system in trailers
• NEO System Diagnosis	NEO System Diagnosis is a modular scalable diagnosis platform comprising diagnosis software and hardware for selected systems in commercial vehicle application. The software can be used as a PC based application or connected with a special workshop compatible laptop

Tabla 7 Productos Knorr-Bremse para Vehículos Comerciales

ANEXO V. Regulación UIC – Union Internationale des Chemins de fer

UIC is an international rail transport industry body which was born on 20 October 1922 with the aim of standardising industry practices. The UIC´s main objectives are to:

- Facilitate the sharing of best practices among members (benchmarking)
- Support members in their efforts to develop new business and new areas of activities
- Propose new ways to improve technical and environmental performance
- Promote interoperability, create new world standards for railways (including common standards with other transport modes)
- Develop centres of competence (High speed, Safety, Security, e-Business…)

Nowadays the UIC has 199 members across 5 continents which can be classified as follow:

- 82 active members (including railways from Europe, Russia, the Middle East, North Africa, South Africa, India, Pakistan, China, Japan, Korea, Kazakhstan, and companies operating worldwide such as Veolia Transport)
- 80 associate members (including railways from Asia, Africa, America and Australia)
- 37 affiliate members (related or ancillary rail transport businesses or services)

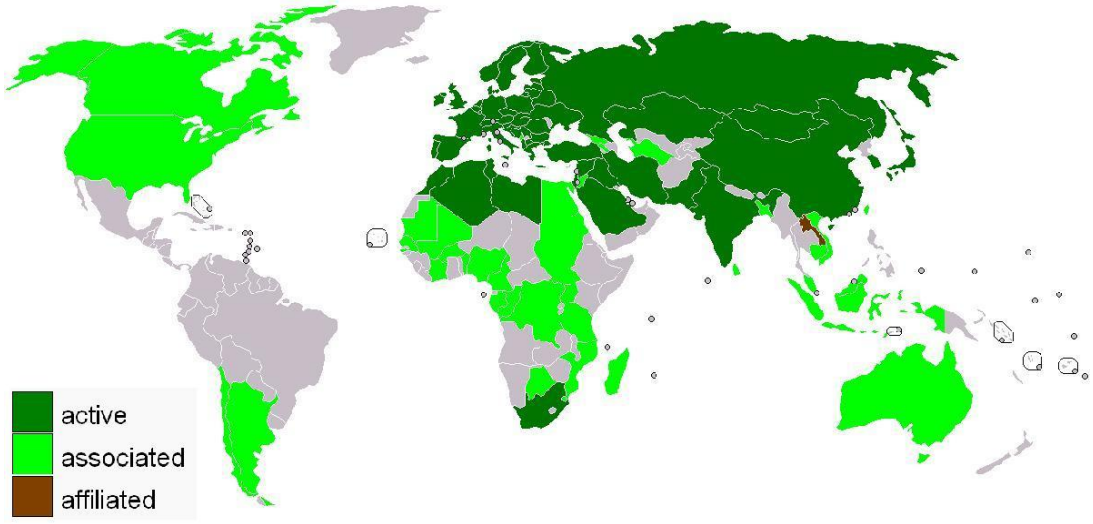


Figura 15 International Union of Railways members

In order to provide a common understanding and reduce potential confusion, the UIC has established standard international railway terminology as well as a trilingual (English-French-German) thesaurus of terms. The thesaurus was the result of cooperation between the European Conference of Ministers of Transport (ECMT) and UIC and was published in 1995.

Classification of railway vehicles has been established by the UIC for locomotives and their axle arrangements, railway coaches and goods wagons.

Some UIC codes are:

- **UIC 568** The 13-corded cable with connector is a standardized connection cable, used transmit data and commands between the locomotive and the carriages of a passenger train.
- **UIC 592-2** Large containers for transport on wagons - Technical conditions to be fulfilled by large containers accepted for use in international traffic. This leaflet defines the technical characteristics and practical features of large containers for use in combined traffic. It describes: the classes and categories of large containers. the handling characteristics, the identification markings, and the special conditions applying to large tank containers.
- **UIC 592-3** Large containers (CT), swap bodies (CM) and transport frames for horizontal transhipment (CA) - Standard report on acceptance tests.
- **UIC 592-4** Swap bodies for grab handling and spreader gripping - Technical conditions Swap bodies are the removable superstructures of road transport vehicles. Their dimensions and some of their fittings are standardised. This standardisation applies particularly to the dimensions, strength parameters, securing devices, of the road vehicle itself, of the wagon and of transhipment arrangements (grab-handling grooves, lower securing parts and, in special cases, upper securing parts).
- **UIC 596-5** Transport of road vehicles on wagons - Technical organisation - Conveyance of semi-trailers with P coding or N coding on recess wagons This Leaflet sets out regulations and provisions to be observed by semi-trailers with normal road transport characteristics for conveyance on fixed-recess carrier wagons. The provisions are valid for: Semi-trailers, Gantry equipment/industrial trucks with grab handles, Recess wagon types 1a and 1b in accordance with UIC Leaflet 571-4.
- **UIC 596-6** Conveyance of road vehicles on wagons - Technical organisation - Conditions for coding combined-transport load units and combined-transport lines The present leaflet sets out the coding and organisation of loading units in respect of road vehicles on wagons. This coding is designed to ensure the compatibility of loading units (LU) with the permissible profile for combined transport lines. The provisions in the present leaflet aim to facilitate LU identification in order thereby to speed-up international traffic movements. They are applicable to: semi-trailers swap bodies roller units loaded on wagons or bogies in combined transport operations.

Structure

Whereas the Whyte notation counts wheels, the UIC notation counts axles.

Upper-case letters	Number of consecutive driving axles, starting at A for a single axle. C thus indicates three consecutive pairs of driving wheels.
Numbers	Consecutive non-driving axles, starting with 1 for a single axle.
Lower-case "o"	suffixing the driving wheel letter. Axles are individually driven by electric traction motors.
Prime sign " ′ "	Axles are mounted on a bogie.

Plus sign "+"	The locomotive or multiple unit consists of permanently coupled and mechanically separated individual vehicles.
Brackets	Groups letters and numbers describing the same bogie. For example, (A1A) indicates a three-axle bogie with the outer two axles driven. When brackets are used a prime is not needed to indicate a bogie. Mallet locomotives can be indicated by bracketing the front power unit — for example, the Union Pacific Big Boy, 4-8-8-4 in Whyte notation, is (2′D)D2′ in UIC notation.

Garratt-type locomotives are indicated by bracketing or placing plus signs between all individual units.

Other suffixes

- h: Superheated Steam (German: *Heißdampf*)
- n: Saturated Steam (German: *Nassdampf*)
- v: Compound (German: *Verbund*)
- Turb: Turbine
- number: number of cylinders
- t: Tank locomotive
- G: Freight (German: *Güterzug* - freight train). Also used to indicate shunting locomotives
- P: Passenger (German: *Personenzug* - passenger train)
- S: Fast passenger (German: *Schnellzug* - express train)

The most common wheel arrangements in modern locomotives are Bo′Bo′ and Co′Co′.

ANEXO VI. Regulación AAR – Associaton of American Railroads

It is an industry trade group representing the major freight railroads of North America (Canada, Mexico and the United States), Amtrak and some regional commuter railroads. Smaller freight railroads are typically represented by the American Short Line and Regional Railroad Association (ASLRRA). AAR was created October 12, 1934 by the merger of five industry-related groups:

- The American Railway Association
- The Association of Railway Executives
- The Bureau of Railroad Economics
- The Railway Accounting Officers Association
- The Railway Treasury Officers Association

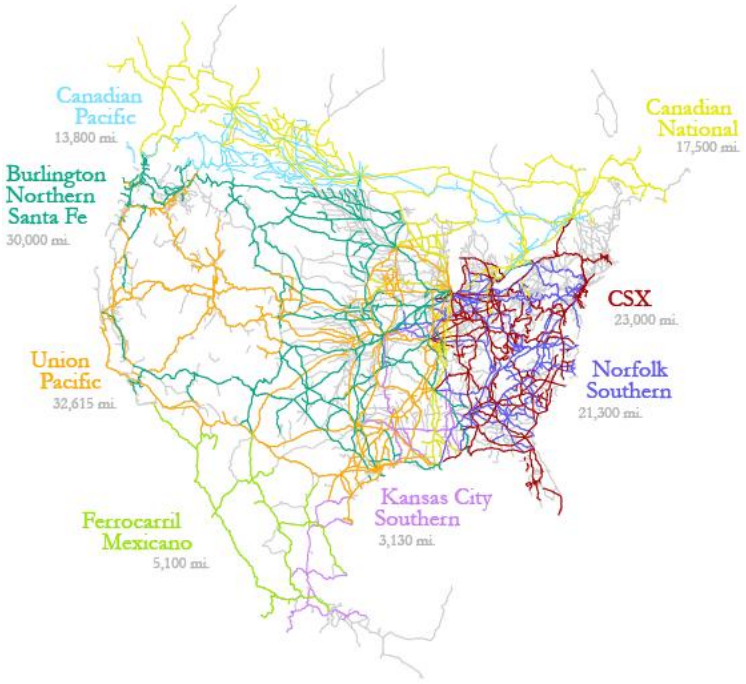


Figura 16 Members of the Association of American Railroads

The AAR represents its members' interests to the public at large and to Congress and government regulators in particular. The AAR works to improve the efficiency, safety and service of the railroad industry, such as through its responsibility for the industry's interchange rules and equipment specifications, e.g. for locomotive multiple unit control[15].

One of the AAR's duties is to oversee the assignment of reporting marks (two for four letter codes that uniquely indentify the owner of any piece of railroad rolling stocker intermodal freight transport equipment.

[15] US Loco MU Control (Railway Technical Web Pages: http://www.railway-technical.com/us-musp.shtml)

ANEXO VII. Noticia del diario alemán Spiegel

07/16/2010 01:10 PM

SPIEGEL ONLINE

Deutsche Bahn Is 'Soft Boiling its Customers'

Since Saturday, air-conditioning systems have broken down on 50 high-speed trains run by Deutsche Bahn, leaving passengers to swelter inside. Commentators blast the company for its treatment of customers and many accuse it of cutting corners ahead of a planned IPO.

It seems to defy logic: An air-conditioning system that stops working when it gets too hot. But that is exactly the misfortune that has befallen many German train passengers this week. As temperatures soared to 38 degrees Celsius (100 degrees Fahrenheit), the cooling system on many ICE high-speed trains simply switched off, leaving passengers to swelter amid inside temperatures of up to 50 degrees Celsius (122 degrees Fahrenheit).

On Thursday, the company admitted that on older ICE trains, the air conditioning could only be guaranteed to work up to 32 degrees Celsius (89 degrees Fahrenheit) while on the newer trains it could only be expected to function up to 35 degrees Celsius (95 degrees Fahrenheit). With the country in the grip of a heat wave, this means effectively that passengers cannot be certain their train won't turn into an unbearable sauna.

Since Saturday the problem has occurred on 50 ICE trains. While a company spokesperson told the DPA news agency on Friday that new air-conditioning units to be installed on the trains would work amid up to 45 degrees Celsius (113 degrees Fahrenheit) that will be small comfort to those facing train journeys in the coming days.

'Days of Chaos'

Nevertheless, the head of the parliamentary transport committee, Winfried Hermann, welcomed the news. The Green party member told the *Mitteldeutsche Zeitung* newspaper that he was happy that there had been a result after the "days of chaos."

At the same time Hermann argued that the debacle could be blamed on the fact that under former CEO Hartmut Mehdorn, the company had exclusively concentrated on preparing for a planned initial public offering. That IPO was supposed to have taken place in 2008 but was cancelled in the wake of the financial crisis. "Only the minimum was invested, as anything else would have messed up the accounts. Now ... the new management has to pay a bitter price," Hermann said.

On Friday, Deutsche Bahn CEO Rüdiger Grube rejected accusations that the company had been penny-pinching. He said spending on long-distance trains between 2004 and 2009 had risen from €298 million ($386 million) to €405 million ($524 million.) "Naturally there is no excuse here," he said, adding that the air conditioning breakdowns were "not acceptable."

With the heat wave set to continue unabated into next week, he said he couldn't promise that there would be no more problems, though the company was making "every effort to ensure that it did not happen again."

On Friday the German press is scathing of the debacle at Deutsche Bahn and many argue that the company has failed its customers in favour of cutting costs.

The center-right **Frankfurter Allgemeine Zeitung** writes:

"Climate change is not a completely new phenomenon. Yet for Deutsche Bahn it seems to come as a surprise that temperatures here can surpass 32 degrees Celsius. What other explanation can there be for the former state company buying trains whose air conditioning gives up the ghost in a heat wave?"

"Even without climate change, 32 degrees Celsius in the shade doesn't seem to be a particularly ambitious maximum. Common sense seems to have been trumped by cost considerations. After all, who can't remember boiling hot summer days that reached these kinds of temperatures in the past?"

"A company that has aspirations to be a high-tech firm, but one which soft boils its customers instead of bringing them comfortably to their destination, has more than a small technical problem."

The left-leaning **Die Tageszeitung** writes:

"The broken-down air conditioning is not the last technical problem that passengers are likely to face. After all, Deutsche Bahn has been cutting spending for years on care and maintenance. At some stage the sloppiness was going to catch up with them."

"Critics of plans to float the company on the stock exchange foresaw exactly this development: In order to present good figures in the short term the DB board repeatedly lengthened the intervals between maintenance controls and delayed individual repairs."

"The company has tried to shift the blame onto the suppliers. Yet during earlier warm periods the cooling systems did not see massive failures. And it is up to the client if the air conditioning systems it orders are only intended to work up to 32 degrees Celsius. After all, trains travel regularly in much hotter countries without passengers having to worry about their health in an unwanted sauna."

The left-leaning **Berliner Zeitung** writes:

"The negative headlines that have accompanied the ICE since its inception have not let up. The ICE, introduced with so many hopes, is now threatening to kill Deutsche Bahn's image. Ever since the politicians and former CEO Hartmut Mehdorn blindly rushed toward their aim of an IPO, the company has had to live with the accusation that because of the efforts to prepare it for the capital market, the maintenance of the tracks and trains and even safety considerations were pushed into second place. Never mind the passengers' comfort and customer service."

"Customers are at the mercy of the Deutsche Bahn system. There is simply no sensible alternative to this mode of transport. The federal government, as owner of the company, has to finally realize this. It has to keep the company more closely in line and, if need be, reprimand it. And it has to invest much more in the railway system than it has until now."

-- Siobhán Dowling

ANEXO VIII. Descripción técnica equipos de aire acondicionado

Air conditioning systems are based on following principles:

- Heat flows from high temperatures to low temperatures
- Heat is absorbed in the phase transition from liquid to gas
- Pressure and temperature are direct related

Based in Molliere cycle (see figure below), there are four important processes:

Compression: Through a compressor, gas is compressed to high pressure.

Condensation: A condensation battery produces a phase transition from gas to liquid at high pressure.

Expansion: Through expansion valve, liquid is expanded. It is a very cold liquid at low pressure.

Evaporation: An evaporator battery produces a phase transition from liquid to gas, where heat is absorbed in order to achieve this transition (this heat is absorbed from the air which passes through the evaporator battery).

For this thermodynamic cycle is possible to use different refrigerant gases as R134a, R407C, R744, R729 and 1234yf.

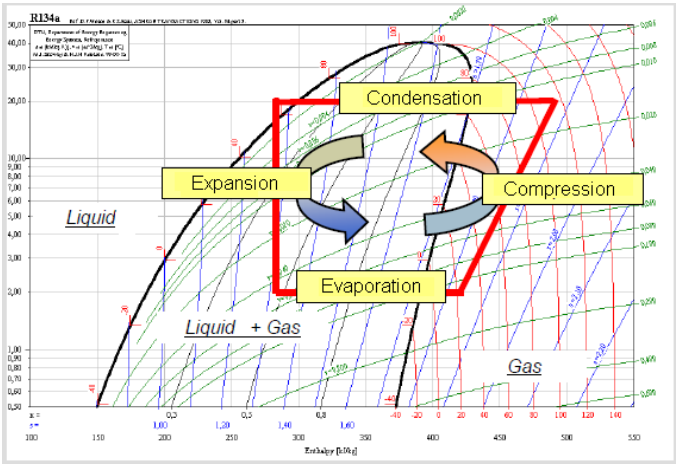


Figura 17 Thermodynamic Cycle

This technical description has been done during my visit to Merak Getafe in October 2010.

HVAC equipments are produced for two different kinds of cars:

- Cabin
- Passenger car

For passenger car HVAC equipments it is possible to divide them into two units, evaporator unit and condensator unit. Depends on this consideration, it is possible to classify HVAC equipments in:

Compact equipment: condensation unit and evaporator unit are together in the same place on the train.

Divided equipment: condensation unit and evaporator unit are installed separately in two different places.

In order to obtain this thermodynamic cycle, HVAC equipment must have next main components:

Compressor	There are different kinds of compressors (semi hermetic compressor, hermetic compressor, rotary screw compressor and scroll). It is a key element which limits the power of whole cycle.
Condensator Battery	Gas which comes at high pressure from the compressor flows through the condensation battery where the phase transition occurs. At this step, liquid at high pressure is obtained.
Expansion Valve	Liquid at high pressure passes through the expansion valve where is expanded to a mix of liquid and gas.
Evaporator battery	Cold air supply (it goes inside the passenger car or cabin) passes through this battery in order to collect the heat from the phase transition liquid-gas which is carried out inside the evaporator battery.

On the other hand, there are also auxiliary equipments whose description is below:

Temperature sensors	Normally there are three different temperature sensors. Two sensors control the temperature for the air in the entrance (air from the exterior of the train but also from the interior of the car, called returned air). The other temperature sensor is in the exit of the HVAC equipment, i.e. in the entrance of cold/warm air to the car.
Security systems:	It is necessary to considerer two situations.

Running at Heating mode: There are usually two temperature sensors. The first one is activated at temperatures from 90°C and it is rearmed automatically when the temperature comes back into the range. The second one is activated at temperatures over 125°C. It must be rearmed manually.

Other important sensor is the low pressure sensor. It checks if the air coming from fan motor is enough (It controls indirectly if the fan motor works correctly).

Running at Refrigeration mode: A pressure switch controls that the system pressure is within a range (normally 3bar<x<20 bar)

Low pressure sensor is also running in this mode in the same way than system running at Heat mode.

In case of control failure, two thermostats which have their limits fixed at a maximum temperature of 24°C and a minimum temperature of 19°C, operate as a control. In case that temperature would be over 24°C and the control would be in failure mode, the system would be in refrigeration mode. In the case that temperature would be below 19°C, it would operate in heating mode.

-*Control systems:* A valve controls the temperature distribution for the evaporator battery because it is important to achieve a uniform temperature. A bypass valve helps this control valve in case it was frozen. Two pressure switches are also used to control the admission air rate.

All these components can be seen in the figure #5.2. The left part is the evaporator unit which is isolated in order to decreases energy losses. On the right, the condesator unit is opened to the environment and it must support situations like rain or snow.

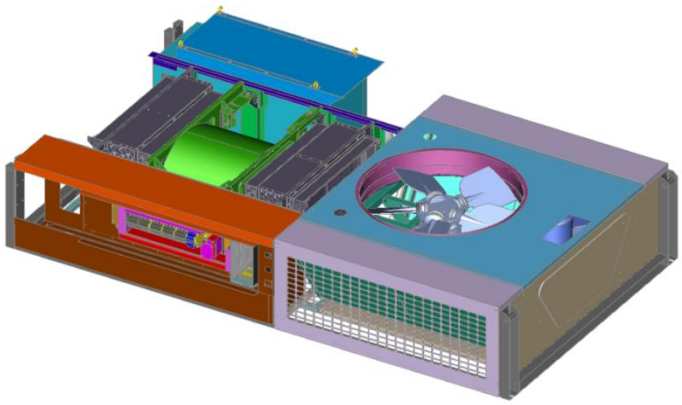


Figura 18 Example of HVAC equipment in Merak Getafe

There are also other auxiliary components that keep the equipment in working order. One of them is a filter (set before the expansion valve) which avoids that possible impurities get to the expansion valve (in this case it could be damaged).

Other important component is the antivibration system. It avoids that vibrations from the compressor can be transferred to the pipes of the circuit. Also the compressor is connected to the frame through dampers in order to improve the structural cycle life (also to avoid noise problems by vibration).

Finally in case of the HVAC equipment is the type four valves HVAC equipment, the system has a four ways valve (or by-pass valve in figure #5.3). In this kind of equipment (unusually used) there is a valve which changes the direction of the thermodynamic cycle (refrigeration cycle or heating cycle) instead of the resistors installed in most of cases which provide heat by Joule effect in heating mode.

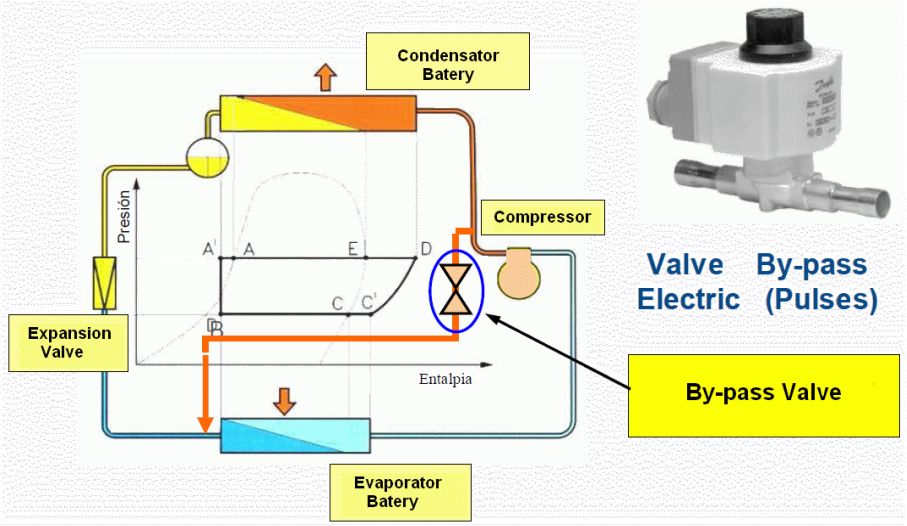


Figura 19 HVAC equipment with 4-ways valve

Auxiliary elements

HVAC equipments need for other complementary installation which can be seen in figure #5.4. Normally these complementary installations are done by the client, because in most cases, they are structural problems.

An important point is the ducts design. It is possible to classify these ducts based on their function:

Warm air supply ducts

Cold air supply ducts

Return air ducts

Exhaust air ducts

For more information about ducts and their calculation see attachment #5.2. During the period which I participated with the system engineering department in Merak Getafe, I calculated the conducts for the train model Bombardier Zefiro.

Other important auxiliary equipment is the overpressure protection damper system. HVAC equipments are a direct connection between the inside of the cars and the area outside the train. It is possible that some aerodynamic pressures generated in a tunnel produce some problems to the passengers inside the train. For more information about Pressure Effects in Railway Tunnel see appendix #5.3.

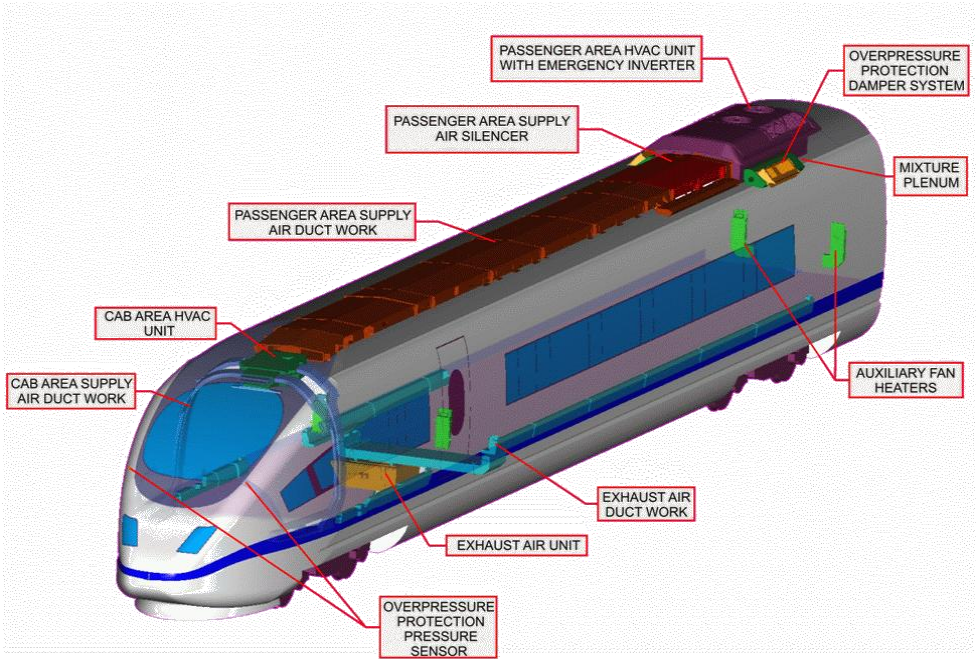


Figura 20 Complementary HVAC installations

ANEXO IX. Descripción y principales hitos en la historia de Merak

Merak es una empresa española perteneciente al grupo Knorr-Bremse que desarrolla equipos de calefacción, ventilación y aire acondicionado para vehículos ferroviarios. Fue fundada en 1963 como oficina representante de "Stone International" y adquirida por el grupo Knorr-Bremse en 2005. Sus oficinas centrales se encuentran en Getafe (España) y desarrolla actividades productivas en Ocaña (España), Westminster (Estados Unidos), Wuxi y Shanghái (China).

Los sistemas de calefacción, ventilación y aire acondicionado producidos por Merak tienen aplicación en metros, cercanías, trenes de media-larga distancia, ferrocarriles ligeros, trenes de alta velocidad y locomotoras. Todos ellos diseñados para una amplia gama de condiciones climáticas.

Year	Main Milestones
1963	Stone Ibérica is founded as a representation office in Spain of Stone International
1965	Start of the commercial activities
1970	First retrofit contract with RENFE
1972	Manufacturing of the first HVAC equipment in Spain
1974	First exports of HVAC equipment
1990	The Fúster family buys up to 35% of the company shares
1991	Emprotech Corp. buys 65% of Stone International shares
1997	Fúster Family buys 65% of Emprotech Corp. shares, holding 100% of the company through Albatros S.L. society. Knorr-Bremse enter the body of shareholders of Albatros with 50%
2000	Stone Ibérica becomes Merak
2005	Acquisition of all Merak shares by Knorr-Bremse
2008	Move from factory in Pinto to newly constructed site in Getafe, shared with Knorr-Bremse sister S.E. de Frenos

Tabla 8 Principales hitos en la historia de Merak

ANEXO X. Nota de prensa de Knorr-Bremse sobre adquisición de Sigma

Press Release

Munich, September 29, 2010

KNORR-BREMSE

Knorr-Bremse strengthens air-conditioning product sector through strategic acquisition

Effective September 29, 2010, the Knorr-Bremse Asia Pacific (Holding) Ltd., a member of the Knorr-Bremse Group, has bought the Australian HVAC systems specialist Sigma Coachair Group (SCG). The move forms part of Knorr-Bremse's long-term strategic drive to expand the company's position in a number of areas through targeted acquisitions. While Knorr-Bremse subsidiary Merak has to date supplied benchmark HVAC systems primarily in China, Europe and the Americas, the acquisition of Sigma Coachair Group will enable the company to access the growth markets of South East Asia, India and Australia in particular. As a result of the acquisition, the Knorr-Bremse Group is now one of the world's leading manufacturers of rail vehicle air-conditioning systems.

Sigma Coachair Group currently employs around 200 people and with annual sales of approximately EUR 50 million ranks among the established developers and manufacturers of HVAC systems. The company maintains production sites in Australia, China, the UK and the USA. The systems built by SCG are mainly destined for rail vehicles, although the company's portfolio also covers industrial applications. With 30 years of experience in the field, SCG can guarantee top quality and excellent efficiency. Long-standing customers include Downer EDI, Bombardier Transportation, Kawasaki Heavy Industries, United Group Hitachi and Hyundai Rotem. The company is also involved in a large number of major projects around the world. These include supplying air-conditioning systems for the new car-sets built by Kawasaki Heavy Industries for the Taipei Metro, as well as for the new metro units ordered from vehicle builder Hyundai Rotem by the Massachusetts Bay Transportation Authority (MBTA), operators of Boston's mass transit network.

For Knorr-Bremse, the acquisition of Sigma Coachair Group is the logical next step in expanding its worldwide air-conditioning systems business. Numerous synergy effects can be expected for both companies, above all in the areas of development and purchasing. The marked expertise of SCG will remain at the company's disposal over the coming years, as key management appointments will be left unchanged.

The Knorr-Bremse Group is the world's leading manufacturer of braking systems for rail and commercial vehicles. For more than 100 years now the company has pioneered the development, production, marketing and servicing of state-of-the-art braking systems. Other lines of business in the rail vehicle systems sector include automatic, electro-pneumatic or electric door systems, air conditioning systems, control components and windscreen wiper systems, as well as platform screen doors. In the commercial vehicle systems sector, the product range includes complete braking systems with driver assistance systems, as well as torsional vibration dampers and powertrain-related solutions such as the Pneumatic Booster System (PBS) and transmission control system for enhanced energy efficiency and fuel economy.

ANEXO XI. Benchmarking

6.1.1 Benchmarking Definition

The chances are that if someone is able to do what you are doing better, faster and/or cheaper, they have different practices than you have. Discovering what those practices are, adapting them to your situation and adopting them is very likely to improve your performance[16].

Benchmarking is the continuous process of measuring products, services and practices against competitors or those companies recognized as industry leaders. More broadly, benchmarking can be applied to any area where we want to compare performance and/or learn from others. Therefore the purpose of benchmarking is to break the paradigm of not being able to learn from others[17].

There are many reasons why organizations benchmark. Some of the more common reasons include:

- As part of an improvement culture
- To short cut the improvement process
- As a driver for improvement
- As an aid to planning/budgeting/target setting
- To solve specific problems
- As a part of a submission for Business Excellence Awards
- To build up a network of like-minded people
- To justify proposals
- To target a Competitor´s Weak Points

Benchmarking has been used as an improvement tool for many years, and the fundamental idea behind its use is simple:

1. Define the project, i.e. the area of the business to be improved
2. Find an organization that does what you want to do better than you can
3. Find out what practices the organization uses that makes them better
4. Adapt and adopt their practices to your situation

In conclusion, a company can gain superiority if it performs a good benchmarking which must try to become it the new benchmark. Dimensions typically measured in order to obtain it are quality, time-productivity and cost. These would be:

- Defect frequency
- Cycle time or quantity of output in relation to time
- Measures of the results of the work
- Productivity

[16] The benchmarking book: a how-to guide to best practice for managers and practitioners, Tim Stapenhurst. Oxford, 2009.

[17] The Benchmarking Book, Michael J. Speldoni. New York: Amacom, 1999.

Different types of benchmarking are described below.

- **Process benchmarking:** activity analysis will be required where the objective is to benchmark cost and efficiency; increasingly applied to back-office processes where outsourcing may be a consideration.
- **Financial benchmarking:** performing a financial analysis and comparing the results in an effort to assess your overall competitiveness and productivity.
- **Benchmarking from an investor perspective:** extending the benchmarking universe to also compare to peer companies that can be considered alternative investment opportunities from the perspective of an investor.
- **Performance benchmarking:** allows the initiator firm to assess their competitive position by comparing products and services with those of target firms.
- **Product benchmarking:** the process of designing new products or upgrades to current ones. This process can sometimes involve reverse engineering which is taking apart competitors products to find strengths and weaknesses.
- **Strategic benchmarking:** involves observing how others compete. This type is usually not industry specific, meaning it is best to look at other industries.
- **Functional benchmarking:** a company will focus its benchmarking on a single function to improve the operation of that particular function.
- **Operational benchmarking:** embraces everything from staffing and productivity to office flow and analysis of procedures performed.
- **Energy benchmarking:** developing an accurate model of building´s energy consumption with the purpose of measuring reduction usage.
- **Internal benchmarking:** it is a comparison among similar operations within one´s own organization.

Benchmarking History

In the industrial world reverse engineering appeared as method of covert benchmarking. Not only did organizations look at the competition and try to improve their products and services, the acquired competitor´s products, dismantled them and learned how to equal or if they could, improve on what they learned. Reverse engineering is nowadays often illegal and the use of information gained by reverse engineering is protected by patents.

One well-know example of reverse engineering was the development of the USSR´s Tupolev Tu-4 Bomber aircraft. In 1944, three American B-29 bombers on missions over Japan were forced to land in the USSR´s. The Soviets decided to dismantle and study both the design and components of the B-29. The Tupolev Tu-4, a close copy of the B-29 flew in 1947.

Other important benchmarking example was developed after the Second World War. Japanese industry was all but non-existent. America and the West in general, did not perceive Japan as a threat and were quite happy to show off their industries. This gave them both an insight into American manufacturing practices – i.e. what their future competition was doing and how they were doing it – and ideas that they could use in their own factories.

Up until the 1970s benchmarking practices were somewhat haphazard and certainly not widely seen as a management improvement tool. Xerox developed and established benchmarking as a tool to drive out waste, drive down costs, and drive up quality. Current benchmarking thinking and practices are firmly based on what Xerox did over 30 years ago.

Business Benchmarking Process

There is no single benchmarking process which has been universally adopted. The wide appeal and acceptance of benchmarking has led to various benchmarking methodologies emerging. One of the earliest methodologies was developed in the book written by Robert Camp[18]. This methodology consists in 12 states to approach the benchmarking that are:

1. Select subject ahead
2. Define the process
3. Identify potential partners
4. Identify data sources
5. Collect data and select partners
6. Determine the gap
7. Establish process differences
8. Target future performance
9. Communicate
10. Adjust goal
11. Implement
12. Review/recalibrate

For the majority of the companies getting the voice of the customer into their products is vital. Therefore the benchmarking activity is for these companies determinated by the critical success factor of a business in relation to satisfying customer requirements. This means it must understand what is best-in-class from the customer´s perspective. Benchmarking helps them to be more successful in achieving total customer satisfaction because:

- It causes us to look outside to the worldwide best achievements. The competition is out there in the global market place.
- It forces a frank discussion how our product compares to the best.
- It reveals best practices that can be adopted by our organization to improve and become the best.
- It provides clear, achievable goals which are highly motivating.
- It requires the support of senior management and thus actively supported by the urgency and resources of the whole organization.

[18] Benchmarking. The search for the Best Practices That Lead to Superior Performance, Robert Camp. Wisconsin. Quality Press, 1989.

Benchmarking Management Process

It is important to understand that benchmarking is a continuous tool, not a one-time action. Therefore benchmarking requires time, money and human resources. In order to obtain a good effectiveness benchmarking must be conducted by a trained set of professionals from outside the organization but practiced by all work teams inside this company.

Due to time and resources constraints it is not possible to perform a benchmarking for the whole business of a company. Because of that it is important to focus the efforts on the areas which provide a highest impact and are critical to the success for the business. It is useful to conduct a study to determinate these areas and it could help us for prioritizing the direction of and encoring the implementation of the benchmarking findings.

There are some points that indicate benchmarking is urgently needed. This kind of situations should be avoided but they are often repeated in the business world:

- Assuming that past success will be reach again automatically in the future.
- Measure yourself against yourself.
- Some loose of the real competition which is translated into loose of the market place.
- Slow products cycles due to lack of clear decisions on products and their characteristics.
- Possible focus only on domestic markets, loosing international vision.

The greatest learning comes from those benchmarking activities that are originated and completed by people most closely involved with the benchmarking subject. These people must see the results first hand, analyse them and introduce them to action. Benchmarking activities need to be put to use, benchmarking should be conducted on the following:

- **Products and services**. This would establish those features and functions desired by customers that are used in product planning, design and development normally expressed as product goals and technology design practices.

- **Business processes**. It should become the basis for business process improvement and reengineering.

- **Performance measurements**. All planning and operational reviews should be presented and discussed toward the benchmarks as a standard agenda item. It is important to guide the organization based on the results of benchmarking products, services, and processes.

There is also another important concept called benchmarking gap. It results from the comparison between a company and the best-in-class organization. The output is a quantitative representation of the difference the company´s performance and the best-in-class.

As it is commented above, there is not only one way to benchmark. But there is a common scheme that could be conducted and it would be the one that follows:

- **Choose what to benchmark.** Identify areas to be benchmarked which provide highest benefits. It is important to prioritize them and flowcharting them for analysis and comparison of practices.
- **Identify whom to benchmark.** Find which companies have better work practices which can be adopted and adapted.
- **Plan and conduct the investigation.** Identify what data are needed and how to conduct the benchmarking study.
- **Determine the current performance gap.** After the benchmarking study, evaluate how much better the best practices are than current work methods.
- **Project future performance levels.** Decide how much the performance gap will narrow or widen in the near future and what repercussions this has for the organization.
- **Communicate benchmarking findings.** Distribute the information obtained before to all the people who can use it, in order to gain acceptance and commitment.
- **Revise performance goals.** Convert found opportunities for benchmarking to operational statements that describe what must be improved.
- **Develop action plans.** Create specific implementation plans, measurements, assignments and timetables for taking action on the best practices.
- **Implementation actions and monitor progress.** Report progress to key process owners and management.
- **Recalibrate the benchmarks.** Determinate where is now the company and compare it with other companies toward be continuously updated and with ongoing industry changes.

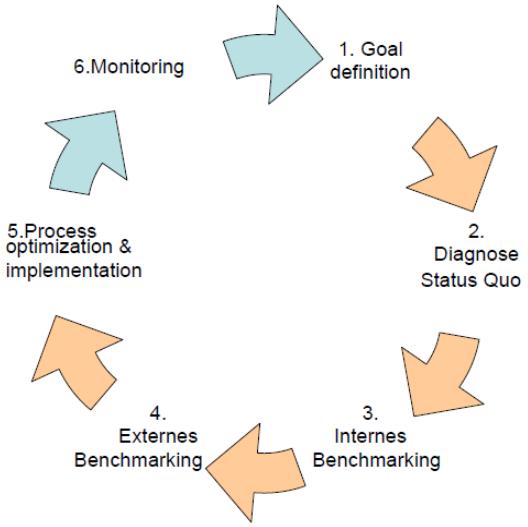


Figura 21 Benchmarking process

Knorr-Bremse Benchmarking

Nowadays Knorr-Bremse is increasing its current wide international presence with facilities in over 60 locations in 25 countries. All these locations have the same structure based on Center of Competences (Brake Control, Bogie Equipment, Hydraulics and Air supply) and on some different areas called on-board Systems (Air conditioning, Door Systems, Informatics/Control Systems, Interior Design Components, Static Converters, Toilet Systems, Warning Systems and Zelisko).

This international vision provides Knorr-Bremse large opportunities to practice internal and external benchmarking whose main goal is to compare performance and learn between different locations not only within Knorr-Bremse organization but also with other companies.

However this report is focused on the internal benchmarking which is carrying out between different areas. External benchmarking is not so structured than internal and sometimes depends on the relationship between different companies.

Internal Benchmarking – Knorr Excellence

In order to conduct an internal benchmarking, Knorr-Bremse uses different tools which provide the framework for all improvement initiatives as STRAP, Q-First, COPE, KPS, GPE, SCE, Progress and GPS. The integration of all these initiatives is developed by Knorr Excellence whose main fields of work are:

- People
- Products
- Processes
- Structures
-

Main Knorr Excellence elements needed to obtain great developments in the fields commented before are:

- To be Best-in-class
- Profitability
- Growth
- Cash Performance

ANEXO XII. Principales hitos en el desarrollo del AMFE

Year	Main Milestones
1940s	FMEA was formally introduced in the late 1940s for military usage by the US Armed
1960	It was applied during the mid-60s by NASA for the space program to avoid errors in small sample sizes of costly rocket technology. Example of this are the Apollo Space program and the program to put a man on the Moon safely
1965	The aircraft industry started using FMEA tools
1975	FMEA was introduced into nuclear power engineering processes
1977	Comprehensive use of FMEA was initiated by Ford in the 70s, after experiencing serious quality faults with the Ford Pinto
1980s	At the beginning of the 80s, Ford published a FMEA method handbook, which laid the foundations for QS 9000 It is standardised in Germany as "Ausfalleffect-Analyse" (DIN 25448)
1996	The System - FMEA method was also described in the VDA It is applied to different industries: Electronics, Software, Chemistry, Pharmaceuticals, Medicine engineering…
2000s	Increasing demand on the application of FMEA by ISO 9000-2000; FDA; GMP etc The increasing application in other sectors also (medicine engineering, electrical engineering, machine tools and food industry) gave rise to the expectation that FMEA will also a Railway Standard. Toyota has taken this one step further with its Design Review Based on Failure Mode (DRBFM) approach The method is now supported by the American Society for Quality which provides detailed guides on applying the method

Tabla 9 Principales hitos del desarrollo del AMFE de Diseño

ANEXO XIII. Tablas de valoración del AMFE de Diseño de Knorr-Bremse

XIII.1 Tabla de Severidad Knorr-Bremse para el AMFE de Diseño

Severity		
10	Dangerous - no warning	Safety Risk. Failure to fulfil statutory regulations, hazard
9	Dangerous - warning present	
8	Very High	Correct operation of the vehicle/equipment extremely limited, immediate visit to workshop mandatory. Function restriction of important subsystems
7	High	
6	Moderately high	Correct operation of the vehicle/equipment limited, immediate visit to workshop not mandatory. Function restriction of significant operation and **comfort systems**
5	Moderate	
4	Low	
3	Very Low	Low impairment of functionality of the vehicle/equipment. Removal at next planned visit to workshop. Function restrictions of operation and comfort systems
2	Insignificant	
1	None	Very low or no impairment of functionality, only detectable by qualified staff

Tabla 10 Tabla de Severidad de Knorr-Bremse para el AMFE-D

XIII.2 Tabla de ocurrencia de Knorr-Bremse para el AMFE de Diseño

Occurrence			
10	Almost certain	Very regular occurrence of problems, unusable, unsuitable design concept	500,000 ppm
9	Very high		100,000 ppm
8	High	The cause of the problem occurs repeatedly. Problematic, ill conceived design	20,000 ppm
7	Moderately high		10,000 ppm
6	Moderate	Increased occurrence of causes of problems. Suitable construction in moderate degree of maturity	3,333 ppm
5	Low		2,000 ppm
4	Very Low		1,000 ppm
3	Unlikely	Moderate occurrence of causes of problems. Suitable construction in advanced stage of maturity	200 ppm
2	Very unlikely		100 ppm
1	Almost impossible	Low occurrence of cause of problem . Approved design	10 ppm

Tabla 11 Tabla de Ocurrencia de Knorr-Bremse para el AMFE-D

XIII.3 Tabla de detección de Knorr-Bremse para el AMFE de Diseño

Detection		
10	Almost impossible	Detecting the cause of the problem is improbable; the reliability of the design cannot be proven. No verification procedure available
9	Very unlikely	
8	Unlikely	Detecting the cause of the problem is less probable, the reliability of the design can be difficult to prove. Verification procedures are uncertain
7	Very low	
6	Low	Detecting the cause of the problem is possible; the reliability of the design could probably be proven. Verification procedures are relatively uncertain
5	Moderate	
4	Moderately high	
3	High	Detecting the cause of the problem is possible; the reliability of the design can probably be proven. Verification procedures are relatively certain
2	Very high	
1	Almost safe	Detecting the cause of the problem is guaranteed, cause of problem determined by several independent verification procedures

Tabla 12 Tabla de Detección de Knorr-Bremse para el AMFE-D

ANEXO XIV. Tabla de modos de fallo del AMFE de Diseño de Merak

MODULO CONDENSADOR	
COMPRESOR	ROTURA DEL COMPRESOR
	FALTA DE COMPRESIÓN
BATERÍA CONDENSADORA	FALTA DE RENDIMIENTO DE LA BATERÍA
MOTOR CONDENSADOR	SOBRECARGA DEL MOTOR
	GIRO AL REVÉS
	DISTORSIÓN ARMÓNICA DE LA TENSIÓN
	TENSIÓN NOMINAL INCORRECTA (CONEX. ESTRELLA TRIÁNGULO)
	CONTACTOR PEGADO
	MOTOR SUELTO POR FISURA DEL SOPORTE DEL MOTOR
VENTILADOR CONDENSADOR	FLUJO DE AIRE DEL VENTILADOR EN SENTIDO CONTRARIO
	ATASCO O ROCE DEL VENTILADOR
OIDO DEL VENTILADOR CONDENSADOR	ROTURA DE LAS PALAS
	FALTA DE REDONDEZ O DE CONCENTRICIDAD
AMORTIGUADORES DEL COMPRESOR	VIBRACIONES Y / O RUIDO
PRESOSTATO DE ALTA	FALLO DE FUNCIONALIDAD (SE QUEDA EN MODO ABIERTO)
	FALLO DE FUNCIONALIDAD (SE QUEDA EN MODO CERRADO)
	PÉRDIDA DE ESTANQUEIDAD
	CONECTOR DE PRESOSTATO NO ESTANCO
ELIMINADOR DE VIBRACIONES DE SUCCIÓN / DESCARGA	LIMITACIÓN DE GRADOS DE LIBERTAD DEL ELIMINADOR DE VIBRACIÓN
	FALLO POR DISEÑO DE INSTALACIÓN (ALINEAMIENTO)
	FALLO POR DISEÑO DE INSTALACIÓN (POSICIÓN RESPECTO A MOVIMIENTO)
	CORROSIÓN DEL CORRUGADO
TRANSDUCTOR DE ALTA / BAJA	FALLO DE FUNCIONALIDAD PROPORCIONANDO SEÑAL INCORRECTA
	ROTURA DE ELECTRÓNICA
	ROTURA MECÁNICA
	PÉRDIDA DE ESTANQUEIDAD
VISOR DE LÍQUIDO	FALTA DE ESTANQUEIDAD DEL VISOR
	INDICADOR NO CAMBIA DE COLOR
	LONGITUD DE TUBERÍA CORTA
	UBICACIÓN DEL VISOR EN LUGAR DE POCA O NULA VISIBILIDAD

ESTRUCTURA DEL MÓDULO CONDENSADOR	OXIDACIÓN DE LA ESTRUCTURA
	NO ENCAJA ADECUADAMENTE EL MÓDULO EN EL BASTIDOR DEL MUEBLE
	ROTURA DE COMPONENTES
	TORSIÓN, FLEXIÓN O PANDEO PARCIAL O TOTAL DE LA ESTRUCTURA DEL MÓDULO
	NO EXISTENCIA DE PUNTOS DE ANCLAJE PARA LEVANTAR EL EQUIPO DURANTE EL MONTAJE
CIRCUITERÍA FRIGORÍFICA	POSICIÓN RELATIVA DE LOS TUBOS FRIGORÍFICOS
	PRODUCCIÓN DE BURBUJAS EN EL VISOR (EFECTO FLASH)
	NO PUEDE CERRARSE LA CIRCUITERÍA O LA SOLDADURA SERÍA INSUFICIENTE
	EXCESIVA DIFERENCIA DE PRESIONES ENTRE DOS CIRCUITOS DE UN MISMO EQUIPO
	ROTURA DE LOS TUBOS DURANTE EL PROCESO DE CONFORMADO
	APARICIÓN DE GRIETAS DURANTE EL PROCESO DE ABOCARDADO
	PROXIMIDAD DE TUBO CALIENTE A MOTOR
	CONDENSACIÓN Y / O GOTEO EN CUALQUIER ZONA DEL CIRCUITO
CIRCUITERÍA ELÉCTRICA	SECCIÓN DE CABLEADO INSUFICIENTE
	CONFUNDIR CABLES DE POTENCIA CON CABLES DE SEÑAL
	PINES O CABLES CAMBIADOS
	ERROR EN LA ELECCIÓN DEL CONECTOR
	ESTANQUEIDAD DEFICIENTE
	NUMERACIÓN DE CABLES MAL DEFINIDA
	SUJECCIÓN INSUFICIENTE DEL CABLE
	INTERFERENCIA EN LAS SEÑALES
DISTRIBUIDOR	DETERIORO DEL OBÚS
	CONFUNDIR LAS TOMAS DE PRESIÓN EN EL MONTAJE
BANCADA DE COMPRESORES	EL COMPRESOR NO PUEDE MONTARSE EN BANCADA
	NO HAY ACCESO A LOS ANCLAJES DEL COMPRESOR CUANDO ESTÁ MONTADO EN EL EQUIPO
	FLEXIÓN DE LA BANCADA DEL COMPRESOR
ARO CONDENSADOR	FALTA DE REDONDEZ O DE CONCENTRICIDAD
	ROCE DEL VENTILADOR CON EL ARO
CAJA Y TAPA DE BORNAS DEL COMPRESOR	ENTRADA DE AGUA
SOPORTE MOTOR CONDENSADOR	ROTURA POR FATIGA DEL SOPORTE

ABRAZADERA COMPRESOR	ROTURA POR FATIGA DE ABRAZADERA
TORNILLERÍA Y ARANDELAS	ROTURA DE TORNILLOS POR FATIGA
	AFLOJAMIENTO DE TORNILLOS
	ARANDELA ERRÓNEA

MODULO EVAPORADOR	
BATERÍA EVAPORADORA	FALTA DE RENDIMIENTO DE LA BATERÍA
BANDEJA BATERÍA EVAPORADORA	REBOSAMIENTO EN LA BANDEJA
	SOLDADURA INCORRECTA
	DERRAME DE AGUA DE LA BANDEJA
BASTIDOR DE RESISTENCIAS	LAS ETIQUETAS SE QUEMAN CON FACILIDAD
	DESCONEXIONES INTEMPESTIVAS DE LOS TERMOSTATOS
	NO LLEGAN A PARARSE LAS RESISTENCIAS
	DERIVACIONES ELÉCTRICAS EN LAS RESISTENCIAS
MOTOR EVAPORADOR	SOBRECARGA DEL MOTOR
	GIRO AL REVÉS
	DISTORSIÓN ARMÓNICA DE LA TENSIÓN
	TENSIÓN NOMINAL INCORRECTA (CONEX. ESTRELLA TRIÁNGULO)
	CONTACTOR PEGADO
	MOTOR SUELTO POR FISURA DEL SOPORTE DEL MOTOR
RODETES	CORROSIÓN GENERALIZADA DEL RODETE
	DESEQUILIBRADO DEL RODETE
	PALAS DEL RODETE EN SENTIDO OPUESTO
VÁLVULA DE BYPASS	FALLO FUNCIONAL DE LA VÁLVULA
	PRODUCCIÓN DE LÍQUIDO DENTRO DEL COMPRESOR
SEPARADOR DE GOTAS	DEJA PASA AGUA A ZONA DE IMPULSIÓN
SONDA DE IMPULSIÓN	MALA REGULACIÓN DE LA TEMPERATURA
	REGULACIÓN INCORRECTA DE LA TEMPERATURA
VÁLVULA DE EXPANSIÓN	MALA REGULACIÓN DE LA VÁLVULA
	PROCESO DE EXPANSIÓN NO ES REALIZADO CORRECTAMENTE
	PROCESO DE EXPANSIÓN NO ES REALIZADO CORRECTAMENTE
PRESOSTATO DIFERENCIAL	FALLO FUNCIONAL DEL PRESOSTATO
FILTRO DE AIRE	PÉRDIDA DE CARGA EXCESIVA POR EXCESIVA SUCIEDAD ACUMULADA
TERMOSTATO DE PROTECCIÓN DE PRIMER NIVEL	NO DETECCIÓN DE SOBRE TEMPERATURA
	INDICACIÓN DE SOBRE TEMPERATURA SIN REALMENTE HABERLA

TERMOSTATO DE PROTECCIÓN DE SEGUNDO NIVEL	NO DETECCIÓN DE SOBRE TEMPERATURA
	INDICACIÓN DE SOBRE TEMPERATURA SIN REALMENTE HABERLA
ESTRUCTURA NUCLEO EVAPORADOR	LA ESTRUCTURA SE FISURA O SE ROMPE
	FLEXIÓN O DEFORMACIÓN DE LA ESTRUCTURA
SOPORTE DEL MOTOR EVAPORADOR	LA ESTRUCTURA SE FISURA O SE ROMPE
	FLEXIÓN O DEFORMACIÓN DE LA ESTRUCTURA
	VIBRACIONES Y / O RUIDO
SOPORTE KLIXON	EL SOPORTE SE DEFORMA
	DETECCIÓN ERRÓNEA DE TEMPERATURA
CIRCUITERÍA FRIGORÍFICA	POSICIÓN RELATIVA DE LOS TUBOS FRIGORÍFICOS
	PRODUCCIÓN DE BURBUJAS EN EL VISOR (EFECTO FLASH)
	NO PUEDE CERRARSE LA CIRCUITERÍA O LA SOLDADURA SERÍA INSUFICIENTE
	EXCESIVA DIFERENCIA DE PRESIONES ENTRE DOS CIRCUITOS DE UN MISMO EQUIPO
	ROTURA DE LOS TUBOS DURANTE EL PROCESO DE CONFORMADO
	APARICIÓN DE GRIETAS DURANTE EL PROCESO DE ABOCARDADO
	PROXIMIDAD DE TUBO CALIENTE A MOTOR
	CONDENSACIÓN Y / O GOTEO EN CUALQUIER ZONA DEL CIRCUITO
CIRCUITERÍA ELÉCTRICA	SECCIÓN DE CABLEADO INSUFICIENTE
	CONFUNDIR CABLES DE POTENCIA CON CABLES DE SEÑAL
	PINES O CABLES CAMBIADOS
	ERROR EN LA ELECCIÓN DEL CONECTOR
	ESTANQUEIDAD DEFICIENTE
	NUMERACIÓN DE CABLES MAL DEFINIDA
	SUJECCIÓN INSUFICIENTE DEL CABLE
	INTERFERENCIA EN LAS SEÑALES
ETIQUETAS	DESPRENDIMIENTO DE ETIQUETAS

PANEL ELECTRICO	
SUBCONJUNTO CHAPA PANEL	FIJACIONES / DIMENSIONES NO ACORDES A LAS REQUERIDAS POR EL CLIENTE
	EN PANELES BAJO BASTIDOR CONDENSACIÓN O FALTA DE ESTANQUEIDAD
BUS BAR O DISTRIBUIDOR DE CORRIENTE	CORTOCIRCUITO O DERIVACIÓN ENTRE FASES
INTERRUPTORES AUTOMÁTICOS	EL AUTOMÁTICO SE DISPARA DE FORMA INTEMPESTIVA
	EL AUTOMÁTICO SE DISPARA CONTINUAMENTE
	EL AUTOMÁTICO NO EJERCE LA FUNCIÓN DE PROTECCIÓN
	EL AUTOMÁTICO NO EJERCE LA FUNCIÓN DE PROTECCIÓN EN CORTOCIRCUITO
CONTACTORES	LA BOBINA SE QUEMA
	LOS CONTACTOS SE FOGUEAN
	FALLO DEL CONTACTO AUXILIAR
BORNAS DE CONEXIÓN	CONEXIÓN FLOJA
BOBINA DE EMISIÓN DE CORRIENTE	LA BOBINA SE QUEMA
CONTACTOS AUXILIARES	FALLO DE CONEXIÓN ELÉCTRICA
CONEXIÓN SALIDA CONTACTOR - BORNAS	ROTURA MECÁNICA
TRANSFORMADOR	QUEMADO DEL TRANSFORMADOR
REPARTIDOR DE POTENCIA	ROTURA MECÁNICA
CABLEADO DE MANDO	FALLO FUNCIONAL DE COMPONENTES
KIT CABLE INTERCONEXIÓN INTERRUPTOR AUTOMÁTICO - CONTACTOR	CONEXIÓN FLOJA
CABLEADO DE FUERZA	FALLO FUNCIONAL DE COMPONENTES
	QUEMADO DE CABLE

ENVOLVENTE DE MODULOS	
DAMPER ELÉCTRICO DE AIRE EXTERIOR	FUNCIONAMIENTO INVERTIDO (CIERRE / APERTURA) DE LAS COMPUERTAS
	ROTURA DE TRANSMISIÓN MECÁNICA
	NO ACTÚA LA COMPUERTA
DAMPER DE RETORNO	FUNCIONAMIENTO INVERTIDO (CIERRE / APERTURA) DE LAS COMPUERTAS
	ROTURA DE TRANSMISIÓN MECÁNICA
	NO ACTÚA LA COMPUERTA
SONDA DE AIRE EXTERIOR	MALA REGULACIÓN DE LA TEMPERATURA
	REGULACIÓN INCORRECTA DE LA TEMPERATURA
SONDA DE RETORNO	MALA REGULACIÓN DE LA TEMPERATURA
	REGULACIÓN INCORRECTA DE LA TEMPERATURA

CONECTORES DE FUERZA	RECALENTAMIENTO / QUEMADO DE CONECTORES E INUTILIZACIÓN DEL SUBCONJUNTO ASOCIADO
	DIFICULTADES AL INSERTAR LOS CONECTORES DEL CLIENTE
CONECTORES DE SEÑAL	FALTA DE CONECTIVIDAD ELÉCTRICA EN CONECTORES
	DIFICULTADES AL INSERTAR LOS CONECTORES DEL CLIENTE

OTROS
RUIDO
CORROSIÓN
FALTA DE PUNTO DE TOMA DE TIERRA O NO ACCESIBLE
LA PUESTA A TIERRA NO TIENE FUNCIONALIDAD O TIENE FUNCIONALIDAD LIMITADA
CONDENSACIONES
INTERFERENCIAS DE ELEMENTOS O SUBCONJUNTOS EN EL MOMENTO DE MONTARLOS EN EL EQUIPO
CONEXIONES FLOJAS
FUGAS DE REFRIGERANTE
LOS PRODUCTOS NO CUMPLEN CON RHOS

Tabla 13 Modos de Fallo detectados en Merak

ANEXO XV. Tablas de valoración del AMFE de Diseño de Sigma

XV.1 Tabla de severidad de Sigma para el AMFE de Diseño

Severity		
10	Hazardous - without warning	Very High Severity - a potential design failure mode results in an unsafe condition that can be without warning
9	Hazardous - with warning	Very High Severity - a potential design failure mode results in an unsafe condition that can be with some warning
8	Very High	Loss of Primary Function - the design will not work, operate or meet its design objective in its application.
7	High	The design will operate but at a significantly reduced level of performance. It will fail to meet its design objective in full in the application. The customer will not accept this situation.
6	Moderate	The design will operate but sometimes at a significantly reduced level of performance. The customer will be dissatisfied with the outcome but may accept compromise.
5	Low	The design will operate at reduced performance in some areas. While not meeting the design goals fully the design performs well. The customer is fairly satisfied but has concerns.
4	Very Low	The design will meet the specification criteria - but not at an optimum level of performance. Customer will and does notice - but has no recourse for complaint.
3	Minor	The design will meet the specification criteria - but not at an optimum level of performance. Some Customers may notice.
2	Very Minor	The design meets the specification criteria - but in some areas - not at an optimum level of performance. Only very finicky customers will notice.
1	None	Design Fully meets all Requirements

Tabla 14 Tabla de Severidad de Sigma para el AMFE-D

XV.2 Tabla de ocurrencia de Sigma para el AMFE de Diseño

Occurrence		
10	Failure is Inevitable	Every - or nearly every design has the same fault
9	Very High - Failure is almost Inevitable	Up to 60% of designs have the same fault
8	Very High - Repeated & Regular Failures	Up to 50% of designs have the same fault
7	High - Repeated Failures	Up to 40% of designs have the same fault
6	High - Sporadic Failures	Up to 20% of designs have the same fault
5	Moderate - Occasional Failures	Up to 10% of designs have the same fault
4	Low - Intermittent Failures over time	Up to 5% of designs have the same fault
3	Low - Few Failures	Up to 2% of designs have the same fault
2	Remote - Failure is Unlikely	Up to 1% of designs have the same fault
1	Remote - Failure is very Unlikely	Less than 0.5% of designs have the same fault

Tabla 15 Tabla de Ocurrencia de Sigma para el AMFE-D

XV.3 Tabla de detección de Sigma para el AMFE de Diseño

Detection		
10	Absolute Uncertainty	There is no current system to detect the problem
9	Very Remote	The issue will almost certainly not be picked up during the Design & Validation Process
8	Remote	There is only a small chance that the issue will be picked up during the Design & Validation Process
7	Very Low	It is very unlikely that the issue will be picked up during the Design & Validation Process
6	Low	There is less than 50% chance that the issue will be picked up during the Design & Validation Process
5	Moderate	There is 50% chance that the issue will be picked up during the Design & Validation Process
4	Moderately High	There is greater than 50% chance that the issue will be picked up during the Design & Validation Process
3	High	It is likely that the issue will be picked up during the Design & Validation Process
2	Very High	It is very likely that the issue will be picked up during the Design & Validation Process
1	Almost Certain	The issue will certainly be picked up during the Design & Validation Process

Tabla 16 Tabla de Detección de Sigma para el AMFE-D

ANEXO XVI. Proceso de verificación de un proyecto en Sigma

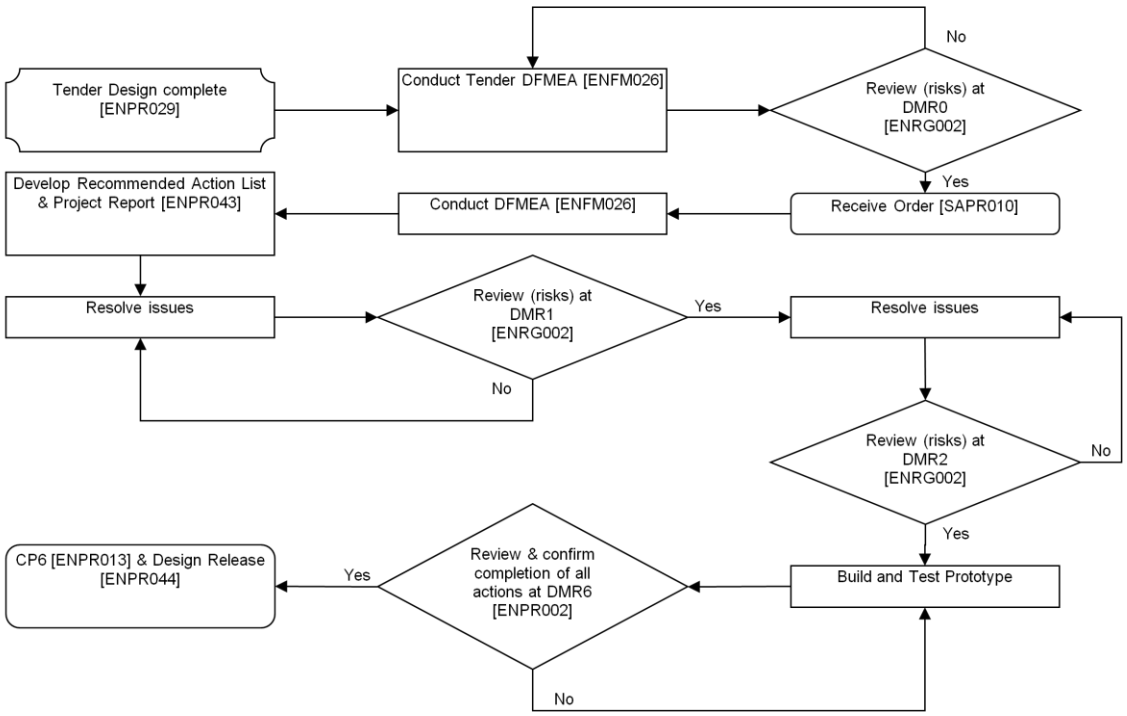


Figura 22 Proceso de verificación de proyectos en Sigma

ANEXO XVII. Tabla de modos de fallo del AMFE de Diseño de Sigma

VENTILATION	
8	Insufficient Supply Airflow
6	Excessive Supply Airflow
9	Insufficient Fresh Airflow
8	No Airflow
8	Airflow reduces over time
8	Insufficient condenser air
8	Airflow fault
8	Supply airflow lower than desired
8	Excessive Evaporator Blower Noise

REFRIGERATION	
8	Compressor fails
8	Loss of refrigerant
8	Insufficient cooling capacity
7	Faulty refrigeration system operation
7	No cooling
7	Excessive cooling
8	Humidity control
8	Crack in evaporator coil flare fittings
8	compressor mounting fails
8	burnt insulation cable of temperature probe

HEATING	
10	Heater element short circuits
7	Heater element open circuit
8	Klixon Trips when not required
10	Klixon does not trip when required
8	Heater C/B Trip when not required
8	Heater C/B does not trip when required
8	Insufficient heating capacity
8	Solid state relay failure - Open circuit
9	Solid state relay failure - Short circuit

Tabla 17 Modos de fallo detectados en Sigma

ELECTRICAL	
8	Inverter failure
8	VSD failure
8	PLC(DDC) failure
8	PLC(DDC) software failure
8	DC/DC Converter failure
5	Sluggish temperature control
6	Temperature probe failure
8	Pressure Transducer failure
8	Failure of wiring terminations
8	Failure of electrical connection plugs
8	Cable failure
8	Contactors failure
8	Circuits breakers failure
5	Incorrect control interface with train signals
6	DDC LCD display failure
10	Interference with cables
8	General failure of electrical components
8	Power surges and power failure
8	Cab condenser fan motor failure
8	PLC (DDC) failure
10	Fire
10	Fire
8	Short circuit
8	Solid state relay failure
5	Reduced airflow or capacity
10	Faulty operation of smoke detector

CASE & COMP	
10	Corrosion
10	Cracking
7	Distortion
10	Structure failure
10	Vibration
8	Unit too heavy
7	Misalignment
7	Failure of coating
8	Poor maintainability
6	Water ingress

NOISE	
8	Excessive external noise
8	Excessive internal noise

WATER	
7	Inadequate water drainage
7	Water in air stream
6	Water ingress into A/C unit from outside
8	Excessive unit condensation (internal surfaces)
7	Condensation on diffusers
7	Water leaks at the discharge pipe in evaporator section
7	Water leakage in evaporator section seams, side access door, pin holes and rivets in the condenser
7	Water ingress into saloon due to Evaporator Tray Drain Trap (Kazoo) being blocked
8	Excessive water accumulation in condenser section
8	Water Ingress

COVER	
10	Cover cannot be secured
9	Condensation on the outside of a cover in a roof space
10	Corrosion
10	Fasteners Failing on Fibreglass Cover
-	Cover breaks
7	Difficulty in fitting cover bolts, especially on evaporator coil cover where seals need to be compressed
7	Condensation forms at low temperature due to lack of insulation on the evaporator cover
10	Cover not sufficiently secured shut

EMERGENCY	
7	Insufficient Fresh Airflow
9	No Emergency Air
9	Emergency Air Operation insufficient Duration

ENGINE BAY	
8	Belt Failure/Skip/Stretch
8	Clutch Failure
9	Compressor bracket bends/breaks
8	Intermediate Pulley bearing fails
9	Intermediate Pulley bracket bends/breaks
9	Compressor/Bracket loose
8	Belt Whip
8	Components do not fit in

PACKAGING & HANDLING	
7	Problem with unit movement
7	No unit drainage
7	Damaged components
7	Cover damage
10	Assembly frame/trolley distortion

MISCELLANEOUS & PROJECT SPECIFIC	
8	Units not produced on time
10	Incomplete manufacturing package and misleading standard cost

ANEXO XVIII. Planificación de la adaptación del AMFE de Diseño Merak-Sigma

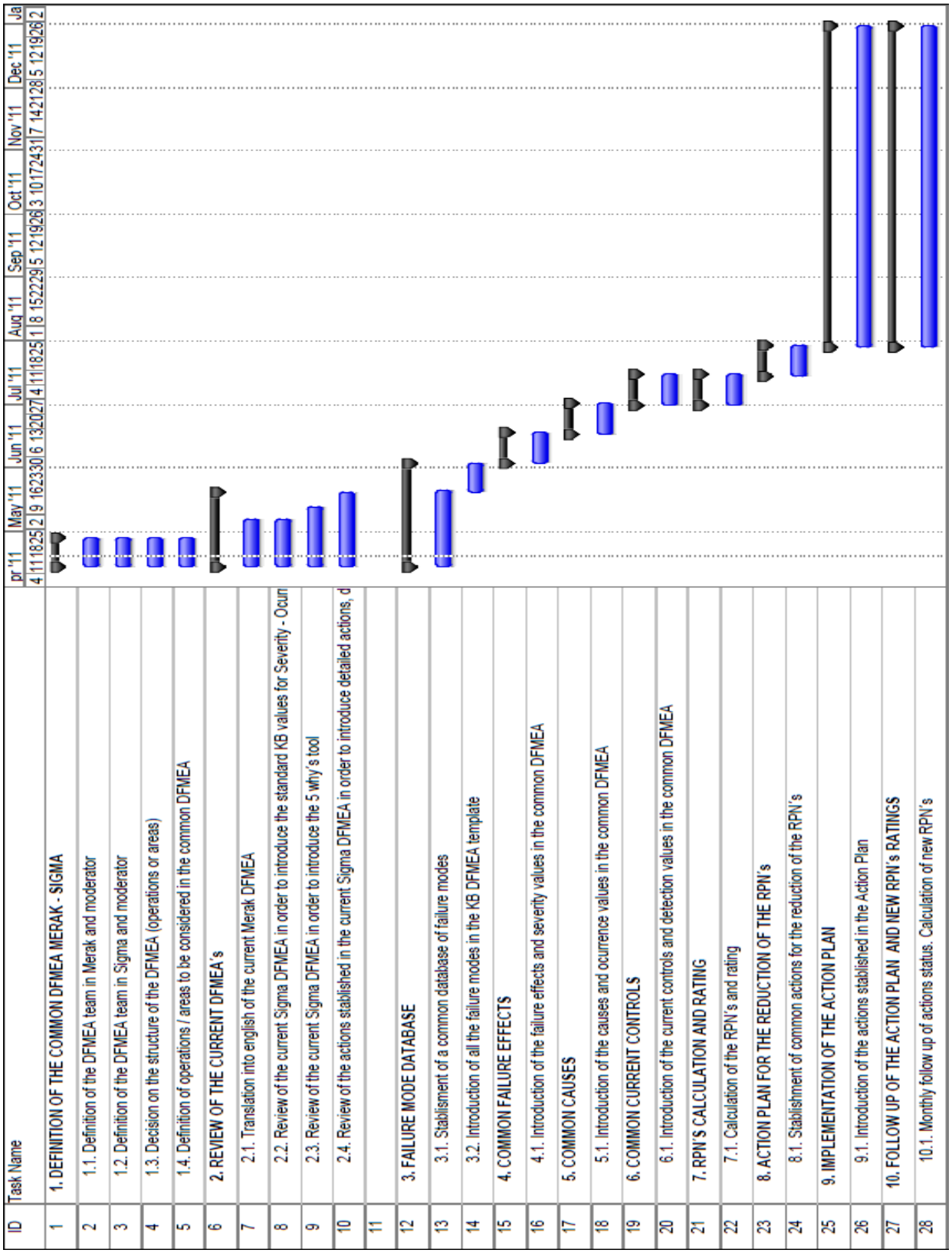


Figura 23 Planning de adaptación del AMFE de Diseño Merak-Sigma

ANEXO XIX. Principales herramientas del Knorr-Bremse Production System (KPS)

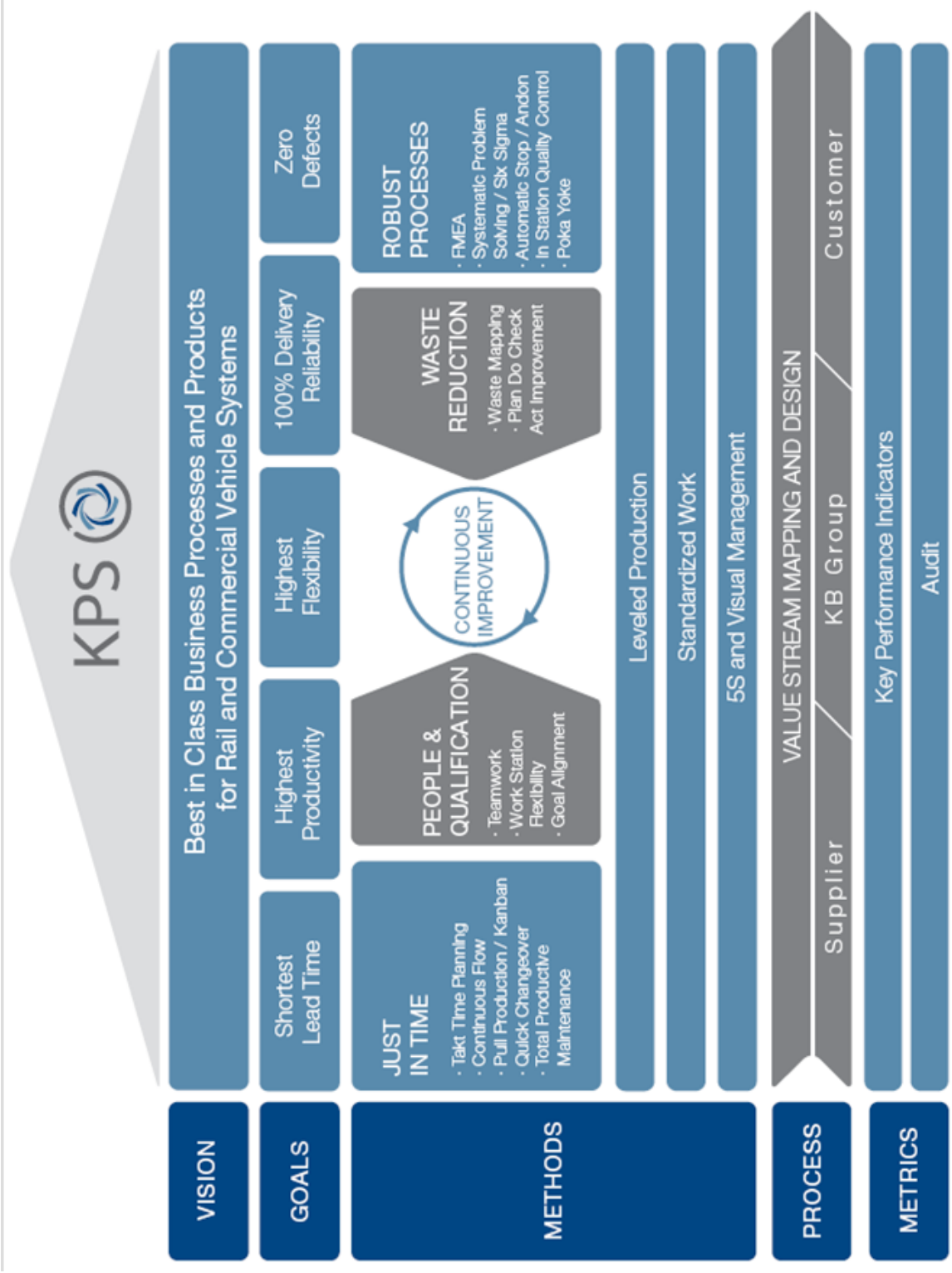
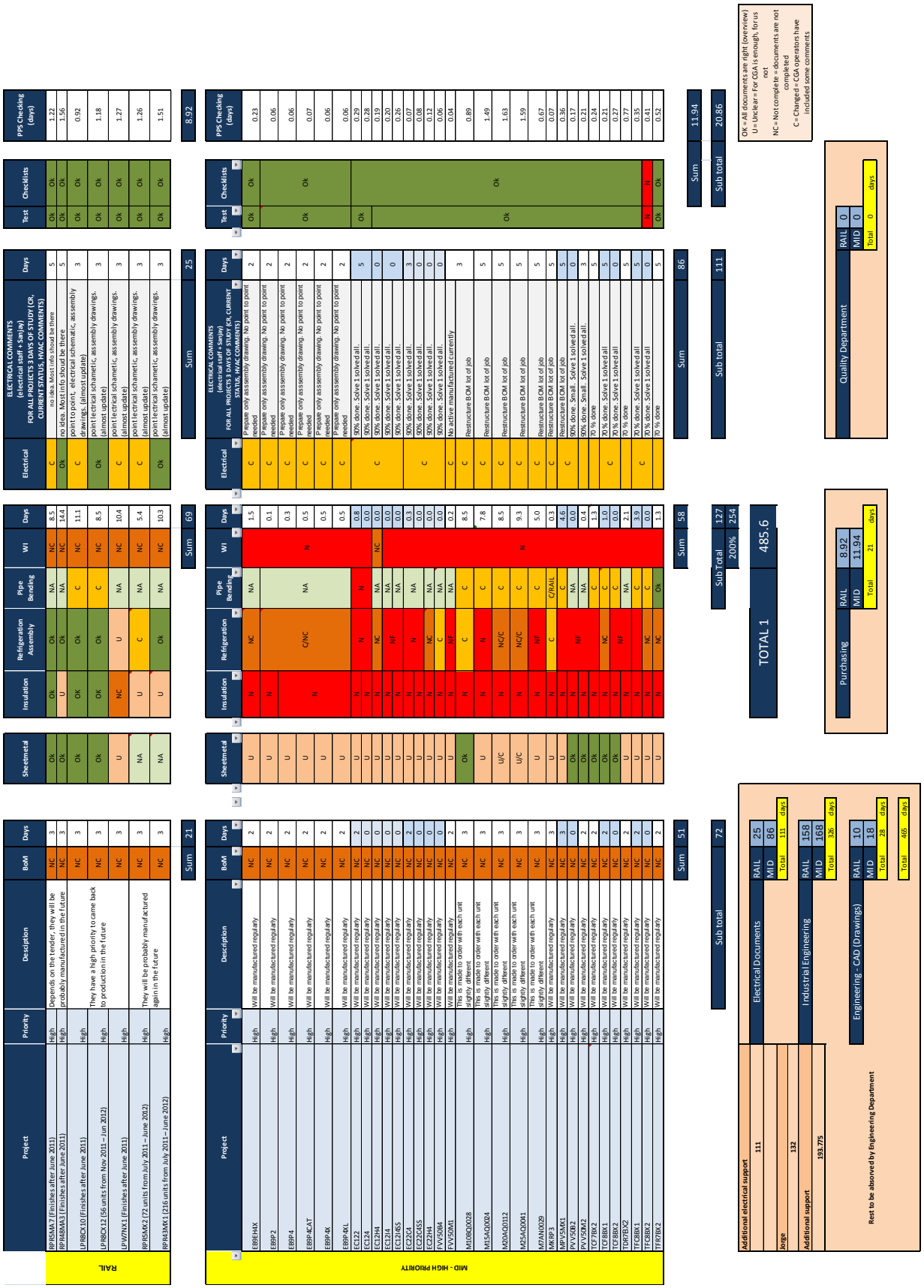


Figura 24 Knorr-Bremse Production System

ANEXO XX. Análisis de la documentación de producción de Sigma



ANEXO XXI. Planificación del proceso de adaptación de la documentación

PRIORITY				
	WI	BOM	Priorit	days remain
RPR43MX1 (216 units from July 2011 – June 2012)	10.25	3	1	351
RPR48MA3 (Finishes after June 2011)	14.375	3	2	319
LPR8CX10 (Finishes after June 2011)	11.125	3	3	294
LPR8CX12 (56 units from Nov 2011 – Jun 2012)	8.5	3	4	274
LPW7NX1 (Finishes after June 2011)	10.375	3	5	250
RPR5MX2 (72 units from July 2011 – June 2012)	5.375	3	6	237
RPR5MA7 (Finishes after June 2011)	8.5	3	7	217
EB9EH4X	1.5	2	8	212
EB9P2	0.125	2	9	209
EB9P4	0.25	2	10	207
EB9P4CAT	0.5	2	11	204
EB9P4X	0.5	2	12	201
EB9P4XL	0.5	2	13	198
EC122	0.75	2	14	194
EC124	0	0	15	194
EC12H4	0	0	16	194
EC12I4	0	0	17	194
EC12I4SS	0	0	18	194
EC22C4	0.25	2	19	192
EC22C4SS	0	0	20	192
EC22H4	0	0	21	192
FVV50B4	0	0	22	192
FVV50M1	0.2	2	23	189
M10BQ0028	8.5	3	24	169
M15AQ0024	7.75	3	25	151
M20AQ0112	8.5	3	26	131
M25AQ0041	9.25	3	27	109
M7AN0029	5	3	28	96
MKRP3	0.25	3	29	93
MPV5MX1	4.625	3	30	81
PVV50B2	0	0	31	81
PVV50M2	0.4375	2	32	78
TCF7BX2	1.25	2	33	73
TCF8BX1	1	2	34	69
TCF8BX2	0	0	35	69
TDR7BX2	2.125	2	36	63
TFC8BX1	3.875	2	37	53
TFC8BX2	0	0	38	53
TFR7BX2	1.25	2	39	49
New project 1	4	2	35	39
New project 2	4	2	36	29
New project 3	4	2	37	19
New project 4	4	2	38	9
New project 5	4	2	39	0
Sum	294	82		
Total	376			

Figura 25 Planificación Proceso de adaptación de la documentación

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ÍNDICE DE FIGURAS

ÍNDICE DE TABLAS