POLITECNICO DI TORINO

Master's Degree in
Engineering & Management

Thesis of Master's Degree

Supplier Quality Engineer

Supervisor

Prof. Domenico Maisano

Signature of Supervisor

.....

Candidate

Syed Fakher Imam

Signature of candidate

.....

December 2018

TABLE OF CONTENTS

ABSTRACT

This Master thesis has been done with one of the biggest companies of manufacturing vehicles. Most of the methods has been set from a lot of years and set as the rules which has been followed enough well, it is not fair to say that these processes are not right because if they are not right, they should not work from first day. The processes need some modification due to some errors in the system.

The thesis consists of two different topics, one is the owners, contractors, and suppliers in the construction industry engage in multiple supplier quality (SQ) practices to ensure that project components are procured to the site with the highest quality possible in order to avoid any rework associated with components that are defective or do not conform to the required specifications.

The second topic is related to criticalities try to improve the supplier portal which uses to communicate between suppler and customer, another criticality is to find the efficient way to set the target of the supplier and for every commodity. These criticalities make the work easy for supplier quality engineer (SQE).

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my advisor Prof. Domenico Maisano for the continuous support of my Thesis, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time writing of this thesis. I could not have imagined having a better advisor and mentor for my thesis.

I would like to thank manager Bruno Valeriano to support me a lot at work and taught me so many new things which helped me a lot to write this thesis, on the other side all the colleagues who encourage me a lot to write this thesis.

Finally, I must express my very profound gratitude to my parents and to my for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Abbreviations

APAC	Asia pacific Economic Cooperation
APQP	Advanced product quality planning
AAR	Appearance Approval Report
BOM	Bill of Material
EMEA	Europe Middle East Africa
CSL	Control Shipment Level
CA	Containment Action
DP	Development Phase
DMFEA	Design Failure Mode and Effect Analysis
FCA	Fiat Chrysler Automobiles
FMEA	Failure Mode and Effect Analysis
MSA	Measurement System Analysis
NAFTA	North American Free Trade Agreement
PP	Production Phase
PPAP	Product Part Approval Process
PSA	Part submission Warrant
PA	Process Audit
PQ	Performance Quality
PFMEA	Failure Mode and Effects Analysis
PSW	Part submission Warrant
PQ	performance quality
PIQ	Performance index quality
PPM	parts per million
PPR	PROCESS PLANNING Review
QRA	Quality Risk Assessment
RFQ	Requirement of Quotation
SQ	Supplier Quality
SQE	Supplier Quality Engineer
SQSoR	Supplier Quality Statement of Requirement
SQCMT	Supplier Quality Transversal Commodity Manager
SQRS	Supplier Quality Sector Manager

1. INTRODUCTION

CNH Industrial is a global leader in the capital goods sector that, through its various businesses, designs, produces and sells agricultural and construction equipment, trucks, commercial vehicles, buses and specialty vehicles, in addition to a broad portfolio of powertrain applications. Present in all major markets worldwide, CNH Industrial is focused on expanding its presence in high-growth markets, including through joint ventures.

During my time with CNH Industrial, I was pushed to find solutions to introduce efficiencies at CNH. I was assigned a contact who I could go to for any day to day issues I faced. I was also given a very warm introduction by another colleague. I also had regular progress checks with a member of the senior management who also motivated me to push to my limits to develop solutions.

This thesis looks to address some of the criticalities in the business at CNH Industrial. One of the main criticalities it looks to solve is the process in dealing with the bills raised by the customer. Another criticality identified is that on the bill raised by the customer the non-conforming column was let at 0 which shouldn't happen. Certain recommendations were made in order to resolve this issue. Additional to this issue, information regarding delivery was also incomplete in some bills, therefore, to tackle this issue another recommendation was made to introduce further efficiencies. Further to the delivery issue, another issue found was the fact that the 48-hour window to receive a reply from a supplier did not consider holidays or weekends meaning suppliers missing the deadline through no fault of their own.

A key criticality around target scores for each supplier was identified to be incorrect. Target scores were set based on the previous year's performance, did not take into account the size of the supplier and the number of individual components delivered per supplier.

The thesis is structured in a way which makes it easy to follow and easily understand the recommendations and solutions identified to the above-

mentioned criticalities. Chapter 1 introduces CNH industrial and its various subsidies such as Iveco, New Holland and Steyr. It also provides a financial report on the previous two years. It also provides information on the competition CNH Industrial faces from other emerging markets such as China, India and Eastern Europe.

Chapter 2 explains the Advanced Product Quality Planning process. It explains each of the individual steps in detail which include the Statement of Requirement, Sourcing Phase, Supplier Assessment, Quality Risk Assessment and others.

Chapter 3 explains the above introduced criticalities in detail and the proposed solutions and recommendations made such as the change to the formula made to determine realistic targets.

1.1 CNH Industrial History

CNH Industrial is a global leader in the capital goods sector that, through its various businesses, designs, produces and sells agricultural and construction equipment, trucks, commercial vehicles, buses and specialty vehicles, in addition to a broad portfolio of powertrain applications. Present in all major markets worldwide, CNH Industrial is focused on expanding its presence in high-growth markets, including through joint ventures.
From tractors and combines, excavators, wheel loaders, trucks, buses, firefighting and civil protection vehicles to powertrain solutions for on and off road and marine, the Group designs, produces and sells 'machines for work'. Across its 12 brands, 64 manufacturing plants, 49 research and development centers and a workforce of more than 69,000 people, CNH Industrial is present in 190 countries giving it a unique competitive position.
The Group has the flexibility to pursue the most advantageous strategic options and capitalize on opportunities for growth and consolidation consistent with our ambitions for it to become a leader in the sector.
The creation on November 12, 2012 of CNH Industrial resulted from the decision of Fiat S.p.A. to group and de-merge its non-automotive vehicle activities; previously, these had been run as two separate Fiat-owned

business units, Fiat Industrial and CNH Global. The new entity's largest shareholder remains Exor, the Agnelli family's investment vehicle, which is also the largest shareholder of FCA N.V. (Fiat Chrysler Automobiles).

Fiat Industrial had been created on January 1, 2011, to oversee Fiat's truck, bus and industrial vehicle engine activities, sold primarily under the Iveco brand name. CNH Global was the holding company for Fiat's agricultural and construction equipment business interests, and had been founded on November 12, 1999, following its purchase of Case Corporation, which it subsequently merged with its New Holland agricultural and construction equipment business.

1.2 CNH Industrial Brands

The new CNH Industrial entity that brought together CNH Global and Fiat Industrial is responsible for 12 brands.

1.3 Case IH

Agricultural machinery is designed and built to deliver efficient power and agronomic advantages to increase yields and limit the cost of inputs. The brand is the choice of professional farmers around the world. Fig. 1.1 is a widely used machine to harvest the fields slight up to the roots and it is a designed as multitask machine.

FIG. 1.1 HARVESTER

The Case IH brand and its iconic red color embody the tradition of leadership in agricultural equipment. Reliability and quality are at the heart of the full line of agricultural equipment, ranging from tractors to combine harvesters and tillage implements. The brand represents more than 170 years of expertise in the industry, including the legacies of Case, International Harvester and David Brown.

1.4 Steyr

FIG. 1.2 KOMPAKT TRACTOR

Steyr has a strong background, particularly in Austria, and an impressive history. Over the past decades the brand's strength has developed, and STEYR has maintained market leadership in the agricultural, municipal and forestry segments, even in times of great change. "Made in Austria" has proven to be a synonym for high quality.

The scope of application of STEYR products is extensive and has grown considerably over the years. Austria's variety of landscapes as shown in Fig. 1.2 has positioned STEYR Kompakt tractors as being flexible, reliable, and efficient across the range of applications.

1.5 Case Construction Equipment

FIG. 1.3 WHEEL LOADERS

In the business of earth moving for more than 170 years, CASE sells and supports a full fine construction equipment around the world, including the first ever factory integrated backhoe loader right through to today's excavators, motor graders, wheel loaders, vibratory compaction rollers, crawler dozers, skid steers, compact track loaders and rough terrain fork lifters. In the Fig. 1.3 wheel loaders are shown to fill-up sand and concrete stuff from the piles to the loader by the use of loader cranes.

1.6 New Holland Agriculture

FIG. 1.4 BIG BALER

New Holland Agriculture has been helping farmers to improve their productivity and efficiency since 1895. Today, Company offers a complete agricultural equipment product offering specializing in livestock, hay & forage, small seed crops, orchards and vineyards. Company has more than 400 models in over 100 product lines. This machine in Fig. 1.4 is used to harvest the small seed crops like orchards and vineyards, this machine separates the acquired seeds from peals and the rest is used as food for livestock animals.

New Holland commitment to supporting the sustainable development of agriculture is at the root of Clean Energy Leader strategy, launched in 2006. This promotes the use of renewable fuels, systems to reduce emissions, technological tools and sustainable agricultural practices.

1.7 New Holland Construction

FIG. 1.5 MINI EXCAVATOR

New Holland Construction is a global construction equipment brand that brings together the strength and resources of its worldwide commercial, industrial and finance organizations.

As shown in the Fig. 1.5 mini excavator is used to harvest the crops like wheat and rice.New Holland can proudly point to quality, technologically state-of-the-art products that are fully compliant with safety standards and environmental regulations.

1.8 Iveco

Iveco vehicles are used all over the world. Company design, manufacture and sell a huge range of light, medium and heavy commercial vehicles for on and off-road use.

FIG. 1.6 DAILY MINIBUS

Shown in the fig. 1.6 is a mini-bus iveco which is used as means of transport for public and private sector employee.

With over 150 years of experience, IVECO has been committed to creating safe, efficient and sustainable vehicles. IVECO is the only brand which are producing, offering ecological diesel and natural gas engines on all our range, and were the first commercial vehicle manufacturer to make a substantial investment in natural gas, developing engines optimized to use CNG.

1.9 Iveco Astra

Extra strong, ready for extreme conditions and easy to set up, repair and maintain everywhere: this is the nature of the most specialized range of vehicles designed for heavy off-road applications in oil & gas, mining, quarry, heavy construction and heavy haulage as shown in Fig. 1.7.

FIG. 1.7 IVECO ASTRA

Established in 1946, Iveco Astra offers the widest range of heavy-duty and heavy-heavy-duty trucks on the market – from tippers to rigid and articulated dumpers. All our products come with a high-yield strength steel chassis structure and a steel cabin to ensure maximum performance, robustness and reliability.

1.10 Iveco Bus

FIG. 1.8 CROSSWAY LOW ENTRY

Iveco Bus a European leader in the development, manufacture and commercialization of buses and coaches, reinforces its international presence and its vocation to succeed worldwide. With vehicles including urban and inter-city buses as well as tourism coaches, minibuses and chassis for bodybuilders worldwide, IVECO BUS supplies some of the biggest names in public transport.

In the Fig. 1.8 crossway low entry bus is shown which is used as tourism bus in between countries and cities as a public transport.

Formed from a merger of the bus divisions of two of the biggest names in the industry, IVECO and Renault, IVECO BUS, with its focus on innovation, advanced technology and best in class manufacturing processes is a name that inspires confidence.

1.11 Heuliez Bus

FIG. 1.9 HEULIEZ BUS

Heuliez Bus still bears the name of its founder, Louis Heuliez, who started manufacturing coaches nearly a century ago. Heuliez Bus became part of CNH Industrial in 2013 because of the merger between Fiat Industrial and CNH Global, but Heuliez Bus retains its brand identity and remains a leader in France and is developing its position in Spain, Switzerland, Belgium, Luxembourg and the Netherlands. In the Fig. 1.9 is a public intercity bus is shown which transport the people from one to another position inside city.

As well as making industry-leading buses, Heuliez Bus also offers spare parts, training courses for customers and second-hand vehicles.

1.12 Magirus

FIG. 1.10 MAGIRUS AIRCORE

Magirus is an international authority on fire fighting and emergency vehicles which is shown in the Fig. 1.10.

Founded by the German fire chief Conrad Dietrich Magirus in 1864, the brand has nearly 150 years of expertise in manufacturing vehicles that provide relief in the case of fire threat, hazard and natural disaster. As the inventor of the turntable ladder, a device present on all major firefighting trucks, Magirus places great important on the development of new e-technologies that allow fire fighter to carry out their tasks safely and efficiently.

1.13 Iveco Defense Vehicles

FIG. 1.11 IVECO DEFENSE VEHICLES

Iveco Defense Vehicles based in Bolzano, Northern Italy, develops and manufactures innovative specialized vehicles for defense and peacekeeping missions as well as for civil protection applications.

The entire range offers the most advanced levels of anti-ballistic and anti-mine protection for the occupants, alongside maximum mobility in extreme circumstances.

Vehicle production is divided into three categories: logistic and tactical trucks, which have been specifically modified for use in extreme conditions, together with multirole and protected vehicles, which utilize state-of-the-art technology in protection and defense applications.

1.14 FPT

Every application needs a powertrain and at FPT Industrial one of the world's leading manufacturers of engines, axles and transmissions. One of the open Genset shown in Fig. 1.12.

FIG. 1.12 OPEN GENSET

Providing a wide range of products (six engine families with a power from 20 to 1000 HP and transmissions with a maximum torque from 200 to 500 Nm), FPT Industrial employs more than 8,000 people around the world in 10 plants and six research and development centers. The company provides commercial network of 93 dealers and more than 899 service points ensuring a presence in more than 100 countries.

1.15 Financial Report

Revenues by segment in the years ended Dec 31, 2017 and 2016. Tab. 1.1 describes the Revenues of 4 different Area.

Area	2017	2016
EMEA	14,627	13,507
NAFTA	6,376	6,244
LATAM	3.099	2,492
APAC	3,845	3,085
TOTAL	**27,947**	**25,328**

Tab. 1.1 FINANCIAL REPORT

1.16 CNH Industrial Competitors

CNH Industrial is facing treats from different companies. Agricultural Equipment and Construction Equipment compete with:

- Large global full-line suppliers with a presence in every market and a Broad range of products that cover most customer needs;
- manufacturers who are product specialists focused on Industry segments on either a global or regional basis;
- Regional full-line manufacturers, some of which are expanding worldwide to build a global presence;
- Local, low-cost manufacturers in individual markets, particularly in emerging markets such as Eastern Europe, India and China.

The competitive strengths of Agricultural Equipment and Construction Equipment include well-recognized brands, a full range of competitive products, and a strong global presence and distribution network. There are multiple factors which influence a buyer's choice of agricultural and construction equipment. These factors include the strength and quality of the distribution network, brand loyalty, product features and performance, availability of a full product range, the quality and pricing of products, technological innovations, product availability, financing terms, parts and warranty programs, resale value and customer service and satisfaction. Agricultural Equipment and Construction Equipment segments continually seek to improve in each of these areas but focus primarily on providing high-quality and high-value agricultural and construction equipment products and supporting those products through their dealer networks. In both the agricultural and construction equipment industries, buyers tend to favor brands based on experience with the product and the dealer. Customers' perceptions of product value in terms of productivity, reliability, resale value and dealer support are formed over many years.

The efficiency of the manufacturing, logistic and scheduling systems of Agricultural Equipment and Construction Equipment are dependent on forecasts of industry volumes and their anticipated share of industry sales,

which is predicated on their ability to compete successfully with others in the marketplace. Our Agricultural Equipment and Construction Equipment segments compete based on product performance, customer service, quality and price. The environment remains competitive from a pricing standpoint, but actions taken to maintain their competitive position in the current difficult economic environment could result in lower than anticipated price realization.In the commercial vehicles business, factors that influence a customer's decision to buy a vehicle include product, parts and aftersales service availability, which is supported by the depth of the distribution network; price, features and performance and durability of products; brand loyalty; technological innovations; availability and terms of financing; and resale value. The ability to meet or exceed applicable vehicle emissions standards as they take effect is also a key competitive factor, particularly in those markets where such standards are the subject of frequent legislative or regulatory scrutiny and change, such as Europe and North America.

Commercial Vehicles competes based on product features and performance, customer service, quality and price. Company believes that Commercial Vehicles' competitive strengths include well-recognized brands, competitively priced products, technological innovations, a strong distribution and customer service network.

In the powertrain business, product competition is driven to a significant extent by developments in emission regulations in the various markets in which Powertrain's products are used.
Principal competitors in the agricultural equipment market are John Deere, AGCO (including the Massey Ferguson, Fendt, Valtra and Challenger brands), Claas, the Argo Group (including the Landini, McCormick and Valpadana brands), the Same Deutz Fahr Group (including the Same, Lamborghini, Hurlimann and Deutz brands) and Kubota.
Competitors in the construction equipment market are Caterpillar, Komatsu, JCB, Hitachi, Volvo, Terex, Liebherr, Doosan, Kubota, Yanmar and John Deere.
In the commercial vehicles business, the Iveco brand principally competes with major manufacturers that have similar product offerings such as: Daimler (including the Mercedes-Benz, Mitsubishi Fuso, Freightliner, Western Star and Bharat-Benz (India) brands), MAN and Scania (both part of the

Volkswagen Group), Paccar (including the DAF, Kenworth, Ken Mex and Peterbilt brands), and the Volvo Group (including the Volvo, Renault, MACK and UD Trucks brands). In the bus business, Iveco Bus and Heuliez Bus's main competitors are Daimler Buses (Mercedes-Benz and Setra brands), Volvo Bus Corporation, MAN (MAN and Neoplan brands) and Scania. In the firefighting business, Magirus' principal competitor worldwide is Rosenbauer International AG. Iveco Defence Vehicles' principal competitors are Rheinmetall, Oshkosh, Navistar, Nexter, General Dynamics, BAE Systems for defense; Mercedes Benz, and MAN in the trucks business. In the heavy-duty equipment business, Iveco and Iveco Astra's principal competitors are Caterpillar and the Volvo Group.

2.Advanced Product Quality Planning

APQP is a rigorous and transparent process, set to involve customers and suppliers in product development activities. There are two phases in APQP process:

- Development Phase (DP)
- Production Phase (PP)

In these two phases there are some steps which shown in the Fig. 2.1 and all steps will describe briefly step by step.

Development verification gates will be implemented for preventing quality and launch readiness issues in order to assure flawless launches and expected quality during product life.

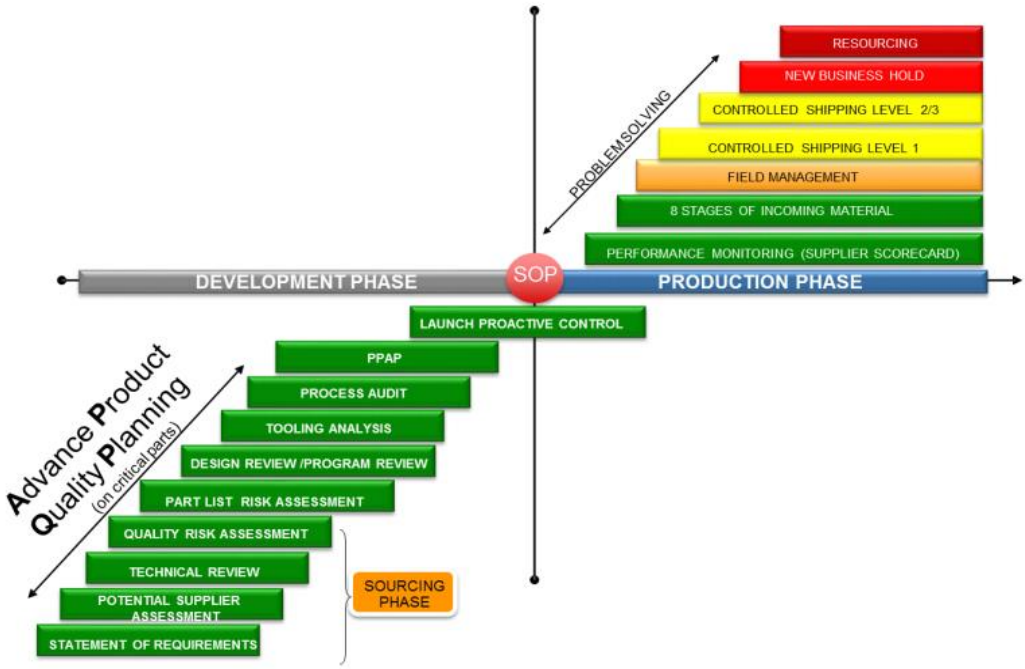

FIG.13 APQP STEPS STRUCTURE

2.1Statement of Requirement

This is first step of APQP planning and Development phase. All the steps are related to statement of requirement are listen down.

- Rigorous Program Management Approach
- Bill of Material (BOM) availability at Program Approval milestone
- Design Release Schedule and readiness follow up
- Full compliance to CNH Industrial Sourcing Procedure
- Risk assessment for APQP parts selection
- Tooling release planning
- Design Validation Plan

2.2 Sourcing Phase

Sourcing phase consists of three different steps, As shown in Fig. 2.2 which will discuss one by one. Purchasing department use selection criteria and supplier evaluation in order to have external partnership able to comply with the quality requirements listed in the Supplier Quality Statement of Requirements (SQSoR). SQSoR is a contractual document included in the Request for Quotation documents (RFQ), shared and signed by suppliers.

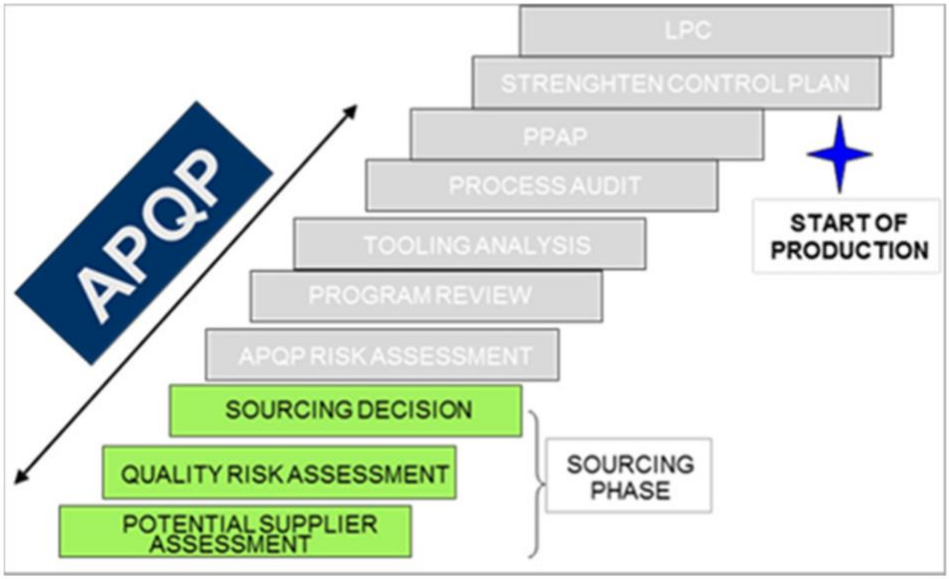

FIG. 2.2 SOURCING PHASE

2.3 Potential Supplier Assessment

PSA is a one-purpose tool, which is assessment of those suppliers who are not currently providing any part to CNH Industrial, so, the evaluation is done on processes dedicated to produce similar parts for the competitors. PSA shall be done before the sourcing phase, to allow new suppliers to take part to it. PSA has to be done once only per product family, even when the supplier has already been assessed for other families. The final score isn't the worst of all the single questions but is calculated as a percentage of fulfillment of the requirements.

2.4 Quality Risk Assessment

The QRA is a SQ tool used during Technical Reviews in order to identify potential quality risks related to each single Supplier involved into the bid. The format takes into account all the main categories of risks occurring during a development and not only, with the aim to guide the SQE in the evaluation. For each category a rating must be defined.

The evaluation could be positive (Approved), negative (Not Source able), or under condition (Conditioned), when applicable requirements are not met but supplier can provide a SQ shared and agreed reaction/corrective action plan. The QRA, together with Technical evaluation expressed by Engineering define the supplier base the Buyer will work with, in order to reach the cost target for the parts.

2.5 Sourcing Decision

Sourcing decision depends on 3 conditions. If the supplier score is green then okay to proceed, if Yellow then it needs business case. If red, then it needs business case and also approval from managers. Fig.16 clears the things much better.

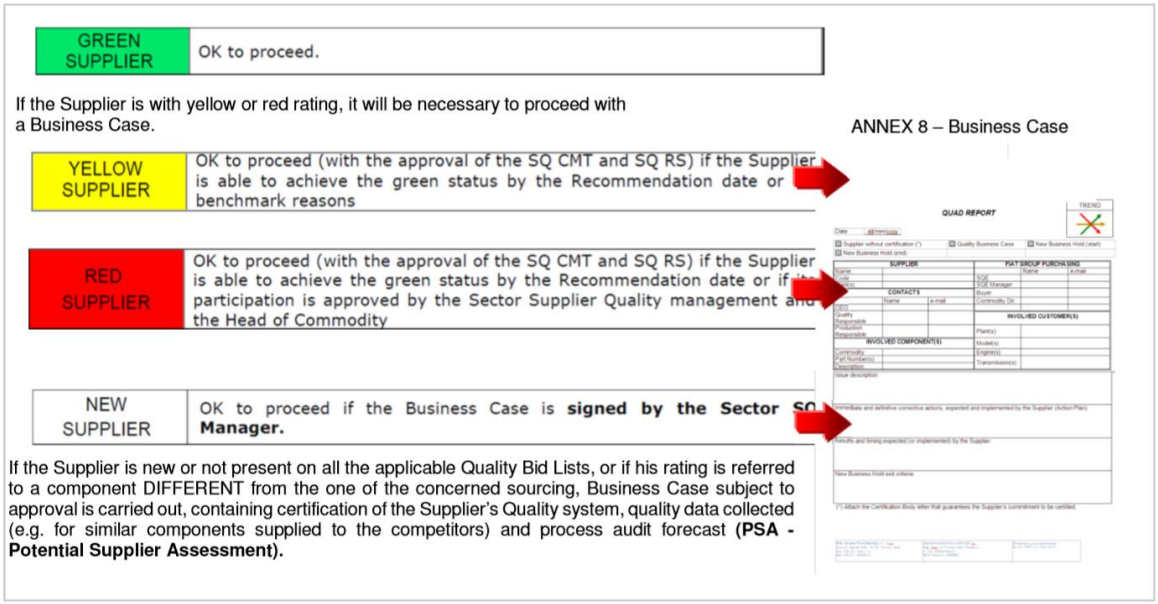

FIG. 2.3 SCORING TABLE

2.6 APQP Risk Assessment

Not all the parts need to be followed by the whole APQP process. So,

it is necessary to identify those components that, for different potential criticalities, have to be considered "high" risk, or – anyway – have to be followed by Supplier Quality.

The APQP Parts list consists of all the High-Risk parts. A separate list will contain the level 4 Low Risk parts. The criteria to include a part in the list is not depending only on its classification (CNH0/1/2).

CNH2 and CNH1 high risk parts are always approved by SQE and normally considered under APQP.

CNH1 low risk parts, with minor modifications, without impact on significant characteristics and on related manufacturing process controls, are approved by either Supplier Quality or Plant Quality in agreement with the decision taken during Platform Risk Assessment.

2.7 Process Planning Review

The Supplier is already defined and in the APQP List. First important activity is to perform the Process Planning Review with the supplier, involving Engineering, Quality, Manufacturing and Product Development. The owner of this key process is the SQE.

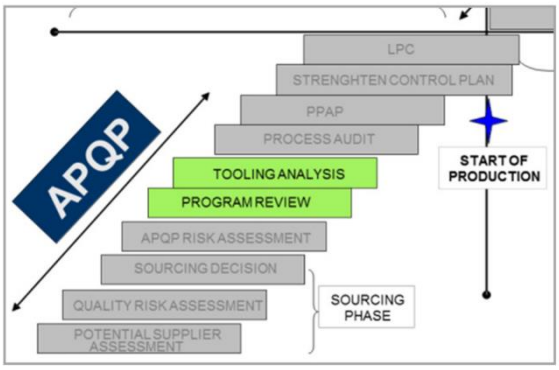

FIG. 2.4 PROCESS PLANNING

The APQP Process Planning Review is the 6 step of development phase that is shown in Fig. 2.4 is a periodic meeting, formalized through a specific format.

The goal is to put in evidence, as earlier as possible, potential job stopper or risk for the project and to identify actions to prevent potential quality issues. First APQP Process Planning Review shall be performed within one month from recommendation date and, further on, depending on program milestones and criticalities. Red status Process Planning Reviews shall be escalated at platform leadership level for evaluation and risk management.

2.8 Process Audit

The PA is a specific process audit developed by Supplier Quality. The SQE auditor shall use the applicable PA form as per applicable procedure is the next step after tooling analysis at supplier factory shown in Fig. 2.5.

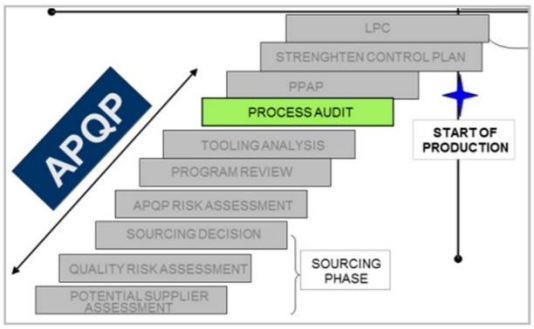

FIG. 2.5 PROCESS AUDIT

The output is the early identification of supplier process control plan weak point that deserve corrective actions within defined periods. Until a PA is positive (≥4), the process audited cannot be considered fully stable and in control. If SQ assign PA=3 it means that temporary containments and additional quality checks are in place to assure that identified control plan weaknesses are adequately under control to not represent risk for product quality. Although

a PA=3, certified by SQE, is sufficient for PPAP submission and saleable production.

2.9 PPAP

This step is the most important step of APQP and almost the last step of production phase as shown in Fig. 2.6.

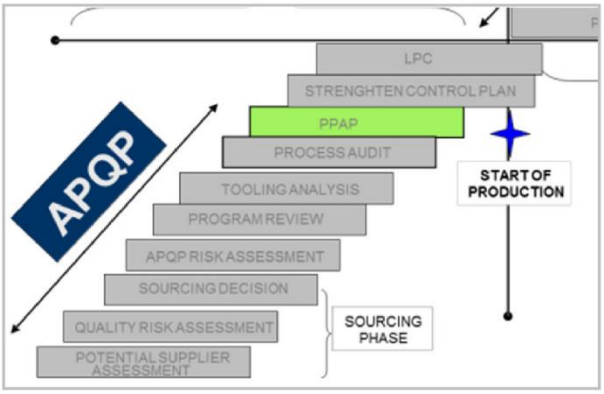

FIG. 2.6 PPAP

To define activities and responsibilities in order to ensure the correct application of PPAP for production purchased components, as well as the process of new projects and current production. To verify that customer requirements are properly satisfied by the supplier. To verify that the supplier production process has the possibility to produce components that meet customer requirements.

2.9.1 PPAP Submission Level AND Responsibility

LEVEL 1	**Supplier Monitored** (Complete Supplier Accountability): Part Submission Warrant.
LEVEL 2	**Supplier Monitored** (Complete Supplier Accountability): Part Submission Warrant with product samples and limited supporting data submitted to CNH Industrial.
LEVEL 3	**Supplier Monitored** (Complete Supplier Accountability): Part Submission Warrant with product samples and complete supporting data submitted to CNH Industrial. Plant approval requested.
LEVEL 4	**Customer Monitored**: Part Submission Warrant with complete supporting data reviewed at the supplier's manufacturing location by Supplier Quality and mandatory verification of the PPAP items at supplier's production lines by SQE.
LEVEL 5	**Customer Monitored**: Part Submission Warrant with complete supporting data reviewed at the supplier's manufacturing location by Supplier Quality and Engineering and mandatory verification of the PPAP items at supplier's production lines (Manufacturing Engineering and Plant Quality on demand)

Tab. 2.1 PPAP levels

Tab. 2.1 is the description of PPAP submission level and responsibility of monitoring. First 3 levels are supplier responsibility and 4th and 5th level are the customer responsibility to monitor.

2.9.2 PPAP Requirement

The Supplier must satisfy all the requirements listed below in Tab. 2.3 from item 1 to item 18 (when applicable), for each product in the approval phase, and submits the evidences to SQ or PQ on the basis of the requested submission level.

RETAIN / SUBMIT REQUIREMENTS FOR PPAP SUBMISSION						
Requirements		PPAP submission levels				
		Level 1	Level 2	Level 3	Level 4	Level 5
1	Design records	R	R	S	R	R
2	Engineering change documentation (ECO/ODM)	R	R	S	R	R
3	Client engineering approval documentation (if requested).	R	R	S	R	R
4	DFMEA	R	R	S	R	R
5	Process Flow-chart	R	R	S	R	R
6	PFMEA	R	R	S	R	R
7	Control Plan	R	R	S	R	R
8	MSA (Measurement Systems Analysis)	R	R	S	R	R
9	Dimensional surveys	R	S	S	R	R
10	Supplier Test Plan - Performance / Material test results - Reliability test (by Supplier)	R	S	S	R	R
11	Statistical process studies (short term capability)	-	-	S	R	R
12	Qualified laboratories documentation: objectives and test accreditation	R	S	S	R	R
13	Appearance Approval Report (AAR)	If required				
14*	Product Samples	R	S	S	R	R
15	Master Samples	R	R	R	R	R
16	List of measuring instruments and checking gauges - Control devices	R	R	R	R	R
17a	Customer Specific Requirements	-	-	-	-	-
17b	Sub-suppliers PPAP management	R	R	S	R	R
17c	Packaging Conformity Certificate	R	S	S	R	R
18	Part Submission Warrant (PSW)	S	S	S	S	S

Tab. 2.2 PPAP 18 REQUIREMENTS

S = Submit

The Supplier shall submit to the Customer an electronic copy of the documentation of the activities performed to complete the PPA.

R = Retain

The Supplier shall retain a copy (electronic or paper copy) of the documentation related to the activities performed to complete the PPAP.

2.10 Performance Monitoring (Supplier Scorecard)

Production phase start from performance monitoring. Every supplier has Rating scale from 0 to 100 for each family of product.

The final status can be Green yellow or Red.

Green= >80

Yellow= The final score will be >60 and <80

Red= <60

2.10.1 Performance Index Quality (PIQ)

Equ.1 Describes the quality of the components. Ratio between the total number of Quality Bills multiplied by their Weight (PQ) and the total number of delivered parts, expressed in parts per million.

$$PIQ = \frac{PQ}{\text{Quantity of delivered parts}} \times 10^6$$

Eq. 2.1 PERFORMANCE INDEX QUALITY

2.10.2 NON-CONFORMING PARTS PER MILLION (PPM)

Ratio between the Quantity of non-conforming parts at the total number of delivered parts expressed in parts per million as shown in Equ.2. A non-conforming part is any part that does not meet customer specifications before any reworking/reprocessing operations.

$$PPM_{NC} = \frac{\text{Non Conforming Quantity}}{\text{Quantity of delivered parts}} \times 10^6$$

Eq. 2.2 PARTS PER MILLION

2.10.3 Quality Impact

10 points subtracted for each CSL1 in status “open” at the Bid List date

25 points subtracted for each CSL2 in status “open” at the Bid List date

25 points subtracted for each CSL3 in status “open” at the Bid List date.

2.11 Stages of Incoming Material

In accordance to 8 Stages of Incoming Material approach, Customer & Supplier are considered as a unique and common process tuned to satisfy Customer Quality expectations, minimizing costs.

The aim is to move from the lower to the higher Stages, shifting controls from product to process causal parameters, making more robust the common process.

Following Tab 2.3 details per each stage, which are the main requirements for Customer plant / Supplier process to assure 100% of components conformity to final Customer.

	SUPPLIER		CUSTOMER	
Stage	Production Department	Inspection Department	Inspection Department	Production Department
0	-	-	-	-
1	-	-	-	100% inspection
2	-	-	100% inspection	
3	-	100% inspection	100% inspection	
4	-	100% inspection	Sampling inspection or check inspection	
5	100% inspection	Sampling inspection	Sampling inspection or check inspection	
6	Process control	Sampling inspection	Check inspection or no inspection	
7	Process control	Check inspection	Check inspection or no inspection	
8	Process control	No inspection	No inspection	

Tab. 2.3 8 STAGES

2.12 CSL

These targets are achieved applying the Restraint Processes called “CSL” (Controlled Shipping Levels) and these steps are middle steps of production phase as easily can see in the Fig. 2.7 that are articulated in three different levels:

- CSL1
- CSL2
- Enhanced CSL2 (CSL3).

FIG. 2.7 CONTROL SHIPMENT LEVEL

2.12.1 CSL Steps

The CSL process can be subdivided into a few time steps:

- Initial assessment
- Process start
- Conclusion.

2.12.1.1 Initial Assessment

The SQE analyzes the non-conformity notices coming from the Factory or Sales Network as concerns the products that showed quality problems that can be charged to the Supplier, then the SQE explains the occurrence to the person in charge.

The non-conformities that can originate a CSL can be indicatively the following ones, without being limited to them:

- Supply quality problems detected in the Customer Factory;
- Supply quality problems detected in the Sales Network;
- Serious lacks that can affect the product quality level, detected by SQE at the Supplier's production site;

The CNH Industrial Management assigns the level to the CSL taking the following criteria in consideration:

- The evidence of one or more product key properties out of tolerance, that can be ascribed to the Supplier's process out of capability, involves the immediate opening of a CSL1 in order to protect the Customer Factory.
- The detection, at the Customer Factory, of non-conformities on a characteristic already in CSL1 status generates the opening of a CSL2/CSL3, according to the seriousness, for the concerned properties.
- In the event of a proved non-compliance of procedures concerning quality and/or of the Control Plans on key properties of the Supplier's production process, a CSL2 or CSL3 is assigned, according to the seriousness.

- In case the Supplier is not able to solve the causes that generated the non-conformities, a CSL3 is applied.
- Variance renewals, repeated due to causes that can be ascribed to the Supplier, lead to the opening of a CSL whose level shall match the seriousness of the problem.

2.12.1.2 Process Start

The actuation of the CSLs is different according to the level of the CSL that is to be opened. The CSL shall be opened for one or more Family Sectors and for a supply code.

2.12.1.3 Actuation of CSL1/ CSL2/CSL3

The “CSL1, CSL2, CSL3 opening form”, signed alternatively by SQE or SQ TL. This form shall be sent also to Business Process (SQ), that records the CSL opening in SQP, and to all the addresses indicated at the foot of the form, among which the plant supplies Audit quality, that is warned about the start of the CSL.

The “CSL1/CSL2/CSL3/NBH closing request.

2.12.1.4 Conclusion

A CSL has a minimum duration of 5 weeks. This period can be modified by Supplier Quality according to the seriousness of the reasons that led to the application of the measure and to the effectiveness of the corrective actions put into effect by the Supplier. The CSL can be concluded only if the Supplier proves that, in this period, his production process has been restored to conformity, that is, it being understood that the responsibilities for closing a CSL is up to Supplier Quality.

2.13 New Business Hold

NBH in the most serious cases involved in the supply quality, CNH Industrial can decide to apply to the Supplier the New Business Hold (NBH) status. This condition involves the failed assignment of Business to the Supplier for the whole duration of the measure. Fig. 2.8 describes clearly the last step of CSL3 also called NBH. In this case shipment can hold temporarily.

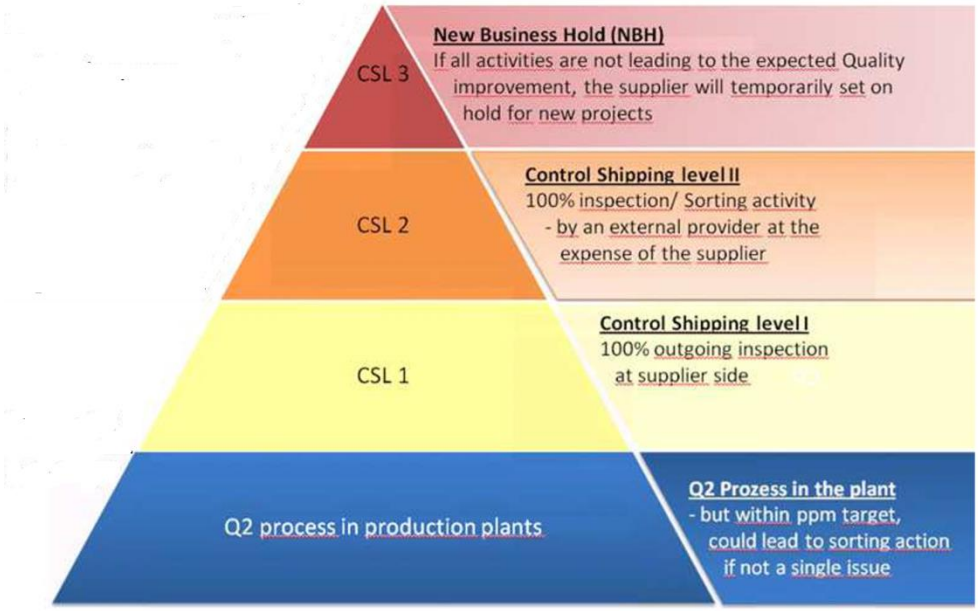

FIG. 2.8 STEPS OF CSL

2.13.1 NBH Opening

SQEM calls a meeting with the Supplier, during which the NBH opening letter is delivered together with the Quad Report. During this meeting, the plan of the actions to be carried out to be released from the NBH status is shared. The NBH opening letter shall be sent also to Business Process, that records the NBH opening in SQP, and to all the addresses indicated at the foot of the form. The NBH is active from the date indicated in the letter.

2.13.2 NBH Closing

At the end of the preset period, the NBH can be closed if the Supplier proves to fulfill the release criteria set in the Quad Report. Before the NBH period is over, the SQE shall carry out a positive PCPA (≥ 3) to certify the improvement.

Finally, if the Supplier proves to have fulfilled the release criteria, he shall send the "CSL1/CSL2/CSL3/NBH closing request" submitting it to the approval of CNH Industrial.

The approved closing request form shall be sent also to System & Data Management and to all the addresses indicated at the foot of the form.

System & Data Management updates the SQP database, recording the closing of the measure and in this way eliminating the "red" status in the Bid Lists concerning the involved codes.

2.14 Resourcing

The Purchasing Procedure is the same of sourcing which has been explained before, the first step of development phase, the rules for Direct Materials Sourcing and Re-Sourcing activities.
The process is designed to ensure that proper communication and coordination occurs between the affected using plants, engineering centers, platforms, and other internal customers when purchasing decides to re-source a part or parts from one supplier to another, consistent with the Purchasing Sourcing/ Resourcing Procedure.

3 CRITICALITIES

3.1 Data handling

3.1.1 Objective

OneDrive for Business is the free, cloud file storage included in Office 365 service for faculty, staff, and students which allows you to store, sync, and share files across multiple devices. You can also collaborate with users on and off campus, and simultaneously edit documents in real time using Microsoft Office or Office Web Apps. To bring the data from an email to a one drive which can be portable when needed from one system to another efficiently without losing any data and time. In the Fig. 3.1 email data can be saved in OneDrive which is easy to access later without losing it.

Microsoft OneDrive for Business is your professional file library—your OneDrive for business needs. OneDrive for Business uses Microsoft Office 365 to safely store your files in the cloud. With your files stored in the cloud, it's easy to share them with your coworkers. OneDrive for Business also makes it easy to access and sync your files from anywhere and from multiple devices.

3.1.2 Benefits of OneDrive

- Store and organize your work files in a secure location in the cloud.
- Share files with your coworkers, so they can review or edit the content. Sharing files this way is much more efficient than attaching them to email messages.
- Synchronize files stored in the cloud to your computer or mobile device (whether you're on the corporate network or not), so that you can access your files offline.

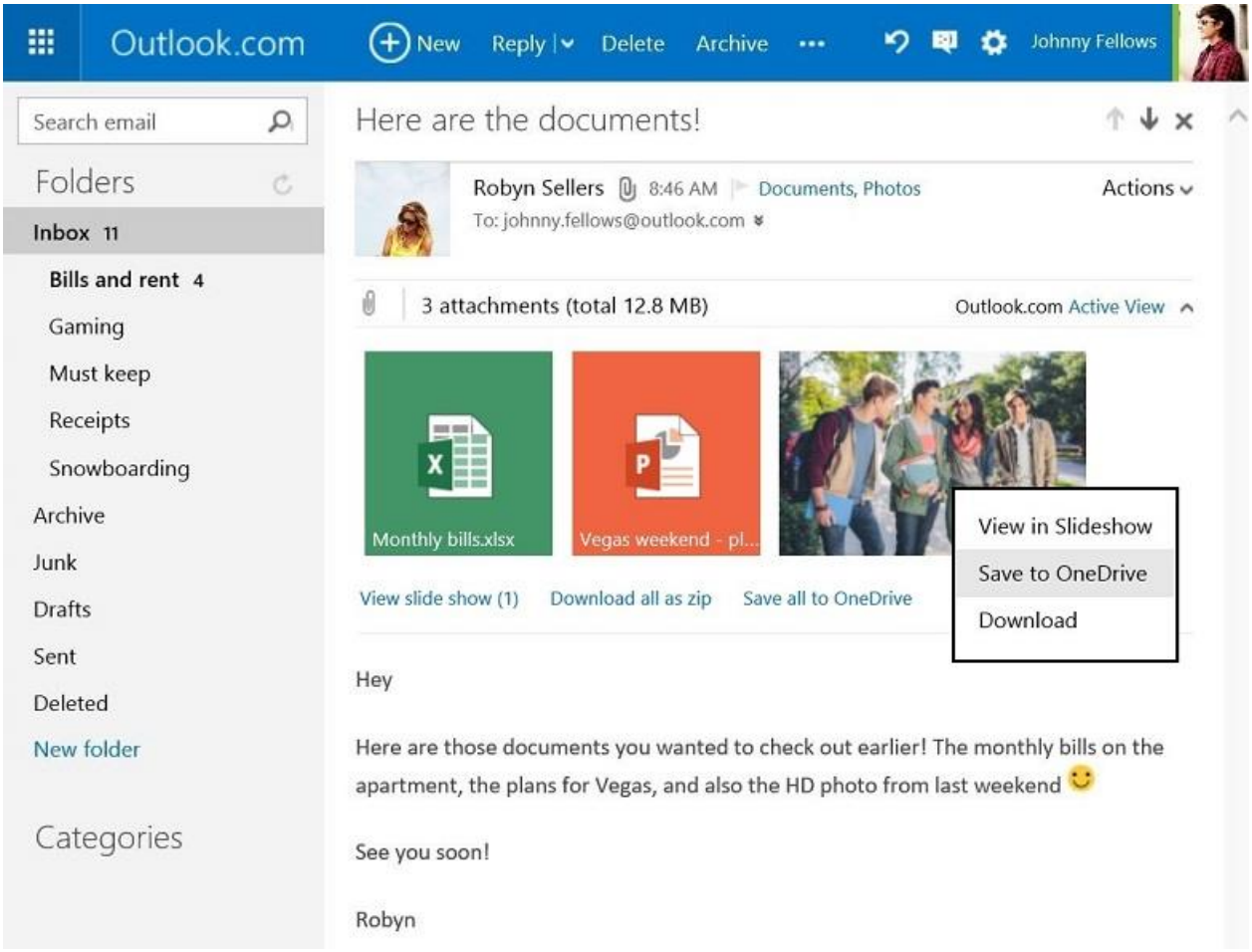

FIG. 3.1 ONEDRIVE

3.1.3 Supplier Portal

The supplier portal used between customer, supplier and SQE. All the 3 players have their own user id and password to login the portal, Fig. 3.2 is the front page of portal. This is communication portal between supplier and customer. All the details related to supplier is very easy to access from this portal.

FIG. 3.2 SUPPLIER PORTAL

3.1.4 Bill Open

Whenever supplier send the customer non-conforming component. In that case customer has to open the bill, in that bill there are every type of information,

- KPI Calculation
- Bill details
- Containment Action
- Revision
- Corrective Action

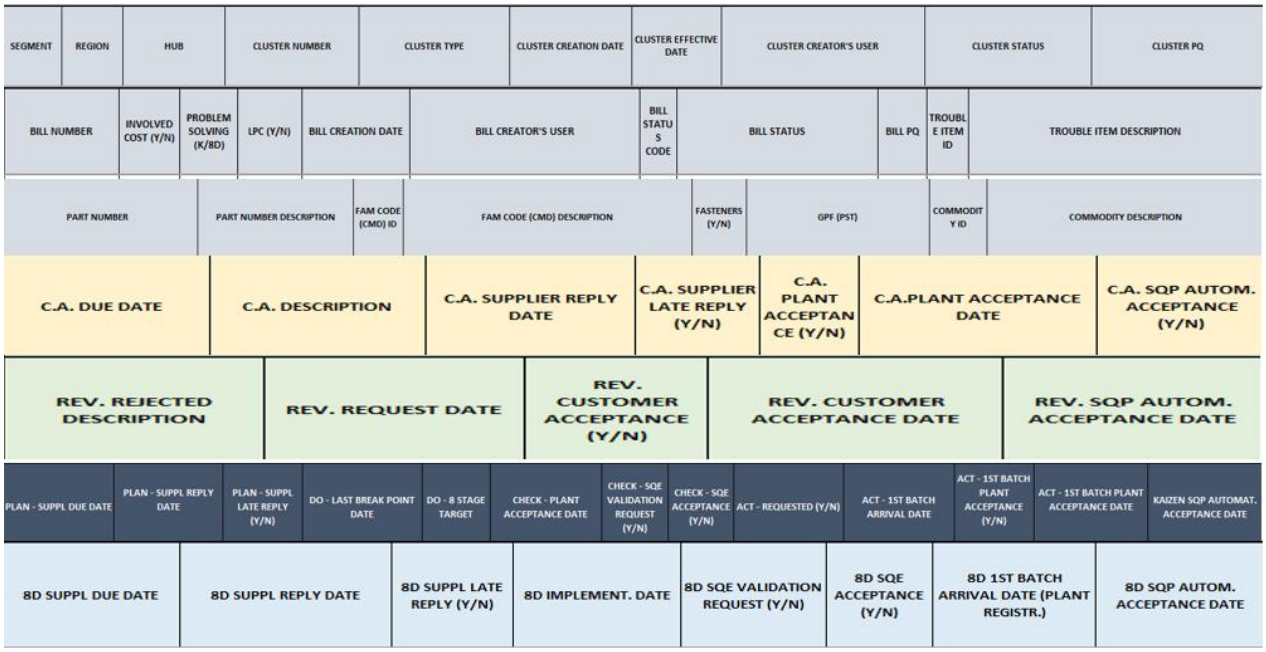

FIG. 3.3 BILL DETAIL

In Fig. 3.3 the first two rows are related to KPI calculation, In KPI calculation the information is who opened the bill, what is the weight of the bill, is it cluster or just the bill, what is the number of the bill.

The third row is related to bill details, which mostly talk about the component.

Fourth row is Containment action, which means when any bill opens by customer then supplier has to give the containment action ASAP, in worst case until 48 hours the supplier has to reply.

Fifth row is Revision which tells that bill has been closed or still open.

Last two rows are related to corrective action which means that if the supplier has accepted that he sent NC component to supplier, so in that case he must give kaizen or 8D report to SQE.

3.1.5 Bill handling

Whenever the bill open then one Supplier quality engineer must follow that bill. The supplier quality engineer has the responsibility to resolve that bill. Supplier must accept the mistake or supplier proofs that component is

according to customer requirement. After that containment action from supplier, as SQE responsibility to request the customer to cross out the bill, otherwise SQE will request to management that delete the bill. In this case SQE give the warning to customer until this date you have to cross out the bill and that bill has to save somewhere.

3.1.6 Purpose to propose

In CNH industrial, each commodity is given a target each year. Each commodity must stay under target of bill(errors). Our commodity was crossing the target, my boss gave to me opportunity to save the warning dates of the bills and make the list of the bills which must delete by management team if the customer does not reply on time. When this work has been handing over to me, in that day I received more than 50 mails from my team and other side. It was quite impossible to handle that date.

Each bill is opened in the supplier quality portal by the plant after examining error in the component. Supplier is requested to take responsibility of this error and close the bill as soon as possible. if supplier proofs that it is not his fault. we have tested the component, and everything is functioning well, so it comes to our plant's responsibility to cross out the bill otherwise it is voided automatically day after.

Each colleague has responsibility to handle a lot of suppliers of themselves so whenever a bill is open, they have to send an email to customer and to me that until this day if you will not cross out the bill then management will delete the bill. I have to make the list of bills and at the end of the day I have to request the management to delete all the bills related to that day.

In this way I used to get plenty of emails to check and open them one by one and find the link of the related bill in each email. This was time consuming and inefficient task.

So, I proposed my colleagues an idea of using one drive and I made folders for each person of group and requested them to put the bill in their own folder

so that I can open each folder one by one and make a list of all the bills at a time. This reduced our potential time and minimized the effort.

3.2 Mistakes on bills

3.2.1 NC=0

Whenever bills have been opened, apart from the other information on the bills, there is one option about the quantities of Non-conforming component.

CLUSTER PQ	NC	CLUSTER ACCEPTED REVIEWED QTY	CLUSTER QTY RETURNED	BILLS INVOLVED (TOTAL NR)	BILL NUMBER	INVOLVED COST (Y/N)	PROBLEM SOLVING (K/8D)	LPC (Y/N)	BILL CREATION DATE	BILL CREATOR'S USER	BILL STATUS CODE	BILL
20	0	0	0	1	2018000033455/1	N	8D	N	29/10/2018 10:59	F43234C-NICOLAS DECRESSAIN	05)	Containm

FIG.3.4 NC VALUE

It was astonishing that the bill is opening with NC component value zero. I try to figure it out that it is not right to open the bill with NC=0 as shown in the Fig. 3.4. In this case SQE has to write the customer that how is this possible that you opened the bill with zero NC component and always we received the answer from customer that sorry we will change it with correct value.

It was waste of time So, I gave the solution to management team that it should not be like this, there use be two modification in that case.

First modification was when any customer tries to put bill, and, in any case, he does submit the value of NC=0, then there should be flag and portal should not allow him to submit the bill.

Second modification that if Component is so big or small, and it cannot send back to supplier factory or it can go back to supplier factory, if component is big then customer needs 1 technician from supplier side. It should describe in the KPI calculation.

3.2.2 Timing of Containment Action

When bill opened by Customer then supplier has to do containment action it means that he has to reply within 2 days, but the problem was if the bill has opened on Friday then supplier has no change to reply within two days

because of weekend. So, I request to management to modify the software if there is weekend then add more 2 days or if there are international holidays then also considered about the holidays somehow the software has to connect with calendar that if there is holiday then consider about it automatically. As in the Fig. 3.5 the C.A due date is on Sunday.

CONTAINMENT ACTION						
C.A. DUE DATE	C.A. DESCRIPTION	C.A. SUPPLIER REPLY DATE	C.A. SUPPLIER LATE REPLY (Y/N)	C.A. PLANT ACCEPTANCE (Y/N)	C.A.PLANT ACCEPTANCE DATE	C.A. SQP AUTOM. ACCEPTANCE (Y/N)
3/11/2018 22:59			N	N		N

FIG. 3.5 CONTAINMENT ACTION

3.2.3 DHL option

As explained before that SQE is responsibility is handling the bill opened by customer and to resolve it ASAP, take into account that the bill weight on supplier and on SQE team. Both have the target, and both has to stay under the target. If it weights on supplier mean the supplier has to replace the component or return the money of that component. If it weighs on SQE then it means SQE team will lose the performance score.

As described before that according to rule the supplier responsibility is to take back the NC component from customer plant but the situation is after weeks when SQE follow the bill and try to contact with supplier about the component. Most of the time supplier reply's that "I did not get the component back at my factory so until now I did not analyze the component"

and I can't take the responsibility of NC component. Then SQE ask to customer where the component is? why you did not send back the component to supplier? They reply this is not our responsibility to send back the component to supplier they have to care about it or they have to give us DHL number to send back the component. So again, SQE has to talk with Supplier that you have to give them DHL number to take back the component back. Then supplier gives the DHL number to customer and then supplier take some days to send back that component. Still there is problem after sending back the

component from customer to supplier factory that SQE does not know about the component where it has arrived, so in this case SQE has to ask again supplier did you receive the component, have you analyzed the component? Sometime the answer receives from them yes and sometime supplier says no we did not receive it.

I share the idea to management team that if we put the option of DHL during containment action from supplier, or there should be option that supplier write I will go by myself to receive the component by myself. In this way SQE will not follow the customer and supplier just put the DHL number on google and get all the information about the component. This way we can save the time and supplier will come to know automatically that his responsibility to take back the component from customer plant.

3.3 Target set

Every company has set their rules, exactly CNH industrial has set their own for supplier. Every supplier has a target and then the supplier must stay under it. Every supplier has score from 0 to 100. The question rises how the suppliers lose their scores.

There are three possibilities losing their scores

- PPM
- PIQ
- CSL

PPM mean the quantity of the NC component. Nominator is the value of NC component and denominator is delivered value of component. Small value has been divided with very large value, so that is the reason to multiply the ratio with 1 million in eq 2.2.

PIQ mean the quality of the NC component because in the formula the nominator is PQ which means how big the mistake is and denominator is total

number of delivered components. In simple words the formula describes the quality of the bill and hence multiplied the value with 1million (eq. 2.1).

There are two types of PPM and PIQ values, set by company which are named as target value and normal value. Score will be decreased from 100 depends on how far normal value is from the target value is?

CSL control shipment value has been described before, it comes into play when supplier start production and if he does the errors two time then SQE open the CSL1, from scoring point of view that supplier will lose certain point from scorecard. If he does the same mistake with same family of components then SQE has to open the CSL2 which will remove the more scores then CSL1, exactly CSL3 will decrease more score then CSL2.

There were so many problems came on front of time

- if small supplier takes just one bill(error) than he turns to Red which means that supplier can never get the business from CNH Industrial.
- Big supplier always gets the more bills and they are always on the top of list, despite the fact supplier sends so many components.

The first problem came because every year one manager decides about the target and set it to be 10 % less than last year, target is divided into 4 commodities electrical, chemical, plastic and metallic. After that every commodity divided further to every supplier. In reality big supplier gets the high target value and small supplier gets very small target value. That's the reason if small supplier gets one bill then they become red and can't get the business anymore.

The second problem came, big supplier sends so many components to CNH industrial and customer open so many bills against them and they are always on the top of the list.

It is true that company has 6000 main suppliers' wholes over the world and it is not so easy to handle all of them, but the problematic thing is the target to set by one manager on the bases of last year performance. Which is quite unrealistic. It was necessary to bring 2 modification of formulas.

$$\text{Target}=\sum_1^n \frac{PQ*NC}{DC}(NODC)=\sum_1^n \frac{PQ*NC}{AVG}$$

Eq. 3.1 TARGET

PQ= Quality bill*PQ weight

NC= Non-conforming components

NODC= Number of Different Components

$\text{AVG}=\frac{NODC}{DC}$

This formula was quite interesting in two ways. First, if there were two different components then there are 2 different drawing as well which means the risk of sending NC components becomes double. So, it was quite astonishing to think more about this formula. If Number of drawing increases means risk of doing mistakes increases, so formula changes shape according to the drawing. The problem came into account when I started putting the real values which showed me opposite face of the formula because I did not take into account the sub components. For example if the color of the component changes mean the drawing also changes, so it does not make the sense to give the double risk if just the component changes the color, the formula needs to be modified, if two components are totally different or just changing the color, it becomes easier to say that they were from same family product or not. The Fig 3.6 will clear all the confusion

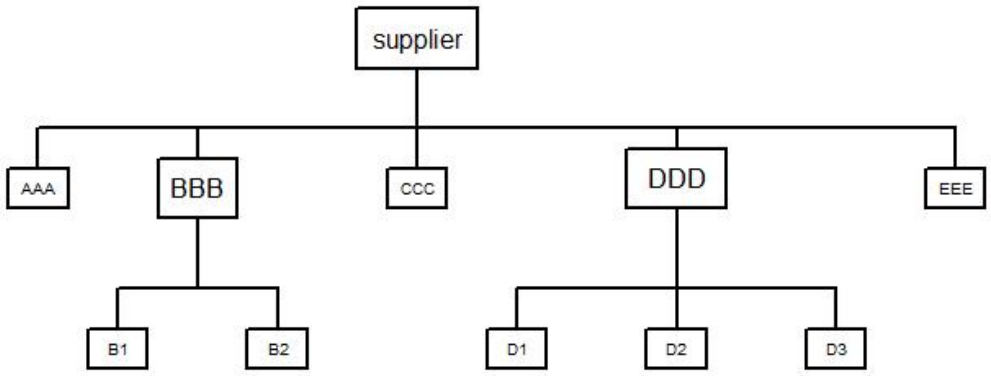

FIG. 3.6 SUPPLIER SHAPE

To bring the modification it is most important to understand about the supplier's relationship with the company. There are a lot number of suppliers and the size of suppliers varies too. Suppliers are bigger in size and send a lot of different components.

As shown in Fig. 3.6 that the supplier sends 5 different types of components consists of two components BBB and DDD which have also sub components.

New Target as shown in Eq 3.2 deals with two different values separately, first all the components are alone, or they do not have the sub components like (AAA, CCC, EEE), second part of the formula deals of the components which have sub components (BBB, DDD).

$$\text{NEW TARGET} = \sum_1^n (\boldsymbol{NODC})\boldsymbol{PIQ} * \boldsymbol{NC} + \sum_1^n \boldsymbol{PPM} * \boldsymbol{NC}(\boldsymbol{X})$$

Eq. 3.2 NEW TARGET

NODC= Number of Different Components

DC= Delivered component

NC= Non-conforming components

PIQ=$\frac{PQ}{DC}$

PQ= Quality bill*PQ weight

$$PPM=\frac{\text{Non Conforming Parts Quality}}{\text{Dilvered Components}}$$

Item	QUALITY BILLS	Responsible	Weight on PQ/PIQ	Impact on PPM_{NC}
22 Q	Foundry defects - Hidden Defects not causing quality issues of major extent in the Process and/or in the Product (Porosity, Inclusions, Gas holes, Carbides) – 8D/Kaizen on demand	Plant Quality	5	YES
23 Q	Foundry defects - Visible defects not causing quality issues of major extent in the Process and/or in the Product (aesthetical, dimensional, etc) . – 8D/Kaizen on demand	Plant Quality	20	YES
42 Q	Foundry defects (Hidden or visible) – Foundry defects causing quality issues of major extent in the Process and/or in the Product .	Plant Quality	40	YES
24 Q	Foundry defects (hidden or visible) - Foundry defects that cause quality problems of major extent in the Process and/or in the Product causing **Stop Shipment / Technical Yard Hold as per QP 10.1.1 Management Alert Procedure**	Plant Quality	90	YES
30 Q	Quality problem of minor/moderate extent, not directly impacting significant characteristics (*). Minor aesthetical reworkable issues. Possible rework activity <2h. – 8D/Kaizen on demand	Plant Quality	20	YES
40 Q	Quality problem of moderate/major extent on the product, with impact on significant characteristics (*), causing loss of production volumes (vehicles / engines), incomplete vehicles.	Plant Quality	50	YES
31 Q	Negative APQP / PPAP results 31Q1. Negative result of Process Planning Review (PPR) with open issues having a supplier responsibility, or in case of missing responsiveness by supplier 31Q2. Negative result of Process Audit (PA) with open issues having a supplier responsibility, or in case of missing responsiveness by Supplier 31Q3. PPAP Level 4/5 rejected due to supplier responsibility	Supplier Quality	Direct impact on Supplier Scorecard	NO
32 Q	PPAP Level 1/2/3 rejected due to supplier responsibility	Plant Quality		NO
33 Q	Quality problem of moderate extent, impacting significant characteristics (*) (FIT / FORM / FUNCTION and AESTHETICAL), not causing job stopper. Rework activity > 2h.	Plant Quality	40	YES
34 Q	Quality problem of major extent on the product causing **Stop Shipment and/or Technical Yard-hold as per QP 10.1.1 Management Alert Procedure**	Plant Quality	90	YES
41 Q	Top worst supplier notification - direct impact on scorecard	Supplier Quality	Direct impact on Supplier Scorecard	NO

Tab. 3.1 DIRECT IMPACT ON SUPPLIER QUALITY

PQ value will take from the Tab 3.1 and plant quality engineer is the responsible to decide the value of PQ. Basically, PQ weight is the value which decide that how big the mistake is done by the supplier.

If the components are from same family means just change the color something like that, it should not have the double risk to send the NC components because process line in the production is the same. So, in this case x value has to multiply with formula but x value will come from Tab 3.6.

The question rises here what the value of x should be, this is not so easy question. What I decided that according to company there are three types of

component CNH0, CNH1, CNH2. CNH0 components are not sensitive ones, so in this case X value should be 1, CNH1 and CNH2 are sensitive components so the value of CNH1 and CNH2 should high than CNH0 as shown in Tab 3.2. CNH1,2 mean the risk to do mistake from supplier will be higher than CNH0.

X	CNH2/1
1	1
2	1.2
3	1.5
4	2
5	2.5
6	3
7	3.5
8	4

TAB. 3.2 TARGET VALUE

As described before that CNH Industrial has more than 6000 main suppliers so it is not so easily to handle with this one formula, but this formula can help to give the estimate of the Target value. So, if there will be estimate value of the target so it is not difficult to set the value of every supplier and if we go behind it also gives the target for every commodity. Now the things seem to be realistic because they are dealing with formulas.

Let's talk about the first problem that if the supplier is so small maybe just one error will make him red and that supplier will never get the business, but not anymore with this formula because the maximum doing of errors will depend on components and how many different types of different components are sending by one supplier.

Second error has been dismissed because of the percentage calculated from the formula put it into right place and not anymore at the top of the list.

Another problem has resolved because the company can set the target with real values which comes from estimated value. Not just give the order to set the target this year 10 percent less than last year or this kind of decision.

I am apologized due to the confidential issue real data cannot be presented.

4. Conclusion

In order to build good relationships between the customers and the suppliers, product quality planning is key which requires rigorous and transparent processes to be in place and also ensuring both parties collaborate in the product development activities. All the steps necessary in the before, during and after production stages have been explained in chapter 2.

The first step is to obtain the correct statement of requirement as this is fundamental to ensure both parties meet and manage to the correct requirements to avoid waste of time and other resources.

To remove uncertainty in the whole process and ensure business continuity, it is essential to identify components which pose significant risks to the organisation. It is the responsibility of the SQE to list parts in the correct classification (CNH0/1/2) depending on their risk factor to be able to assure good quality in the production. Another step to ensure quality in the production include the sourcing phase to assess a potential supplier to further assure the quality.

One of the most important steps in the APQP is the PPAP. It defines activities and responsibilities in order to ensure the correct application of PPAP for production purchased components, as well as the process of new projects and current production. To verify that customer requirements are properly satisfied by the supplier. To verify that the supplier production process has the possibility to produce components that meet customer requirements. The supplier must satisfy all 18 requirements which have been listed in Tab 2.2 and the documentation of the activities performed must be sent to the customer and be retained by the supplier to complete the PPAP

The performance of suppliers is monitored (scorecard) to ensure continuous quality assurance. Each supplier has a rating from 0 to 100 for each family of products, to measure the performance index quality of the components, the ratio between the total number of Quality Bills multiplied by their weight (PQ) and the total number of delivered parts expressed in parts per million.

All other steps such as the Sourcing Phase, Process Planning Review, Process Audit, Stages of Incoming Material, Controlled Shipping Levels, New Business Hold and Resourcing have also been explained in chapter 2.

Moving on to chapter 3 which relates to the criticalities at CNH Industrial. Each supplier, customer and the SQE have access to the supplier portal which they each use their unique user id and password to login. It also acts as a communication portal between the supplier and the customer.

When a non-conforming component has been identified by a customer from a supplier a bill is opened on the portal where information regarding the bill details, KPI calculation, containment action, revision and corrective action is contained. As fig 3.3 shows, in the KPI calculation information regarding who generated the bill, weight and number of the bill is stored. The bill detail has information regarding the specific non-conforming components. The containment action must be populated by the supplier within 48 hours of a bill being raised. Once the supplier has accepted a non-conforming component being sent to a customer a kaizen or 8D report is sent to the SQE and is contained in the corrective action in the bill.

Working with the bills, a recommendation was made to improve efficiency within the business such as using one drive to store individual colleagues' dealings with bills rather than following chains of emails. As the QSE this saved time and effort in locating the correct emails.

One of the mistakes identified on the bills was the fact that the non-conforming column (NC) was left at 0 as shown in figure 3.4. In this instance, the SQE has to write back to the customer which wastes a lot of time. A modification was issued where a customer shall try to insert a value of NC = 0, a flag shall be raised, and the portal will not allow the customer to submit the bill. As the supplier has a 48-hour window to reply to the raised bill, in some instances where a bill has been raised on a Friday, it is not possible to reply within the time limit, therefore a recommendation was issued that the software be updated to connect with calendar to give sufficient time for the supplier to reply. A further recommendation was made to include DHL delivery information in the containment action regarding the delivery of components as the suppliers were very slow to issue DHL delivery

information. This further added efficiencies to the SQE as time was saved not chasing suppliers to provide delivery information.

The suppliers have 3 main ways to lose their scores from a maximum of 100. The PPM, PIQ and the CSL. PPM refers to the quantity of NC components. PIQ refers to the quality of NC components and CSL refers to repeated mistakes. As CNH industrial has over 6000 suppliers, it is not easy to set target scores for each of them due to their range of size. The first problem with target scores is the fact that it is based on previous years' performance and a 10% reduction is set as next year's target. This means in reality the big suppliers have high targets and small suppliers have low targets therefore, if a small supplier is issued with even 1 bill it becomes red and cannot generate business. The second problem identified is as large suppliers send a large number of components, they will also have large amounts of bills issued against them meaning they stay at the top of the list. To solve these problems and to set realistic targets, the formula was modified as seen in Eq 3.1 to Eq 3.2. The new formula considers the size of the supplier and how many different types of components are being sent by the same supplier. This has allowed for realistic targets to be set rather than estimates based on previous year's performance. It has also meant the list of bills is in order of highest percentage of NC components and not in order of bills raised.

Due to confidential reasons the data cannot be presented.

BIBLIOGRAPHY

References to public documents

- (Isabella Zell and Niklas Johansson,2012, “A Supplier Quality Performance Tool”, Thesis)
- (Yoshua Neuman,25 Mar 2014, “A Quantitative analysis of supplier quality in the engineer procure construct”, Thesis)
- (Dr. V.S Majali,2012, “Supplier Quality Management System for Automobile Industry”, Article)
- (Laura M. Birou, Stanley E. Fawcett, 1994, “Supplier Involvement in Integrated Product Development”, Journal)
- (Manufacturing Organization,14 Nov 2018, “Effect of Supplier Quality Management (SQM) on performance measures of manufacturing organization”, Article)
- (Andrew, G. S., 1994, “Supplier Audits as Part of a Supplier Partnership”, Magazine)
- (Fernandez, R.R. ,1995, Total Quality in Purchasing and Supplier Management, Article)
- (Trent, R. and Maczka, 1999, “Achieving World Class Supplier Quality and Total Quality Management”, Journal)
- (S.N. Teli, V.S. Majali, U.M. Bhushi, 2012, “Supplier Performance Evaluation and Monitoring Through PPM to Reduce Quality Cost”, Book)
- (Yoshua Neuman, 12 june 2015, Quantitative Analysis of Supplier Quality Surveillance Practices in EPC Projects, Thesis)
- (I-Ki Yeung and Kwai-Sang Chin, 2004, “Critical Success Factors of Supplier Quality Management, Asian Journal on Quality”, Thesis)
- (Ramanathan, 2007, “Supplier Selection Problem: integrating DEA with the approaches of total cost ownership and AHP” Supplier Chain Management”, An International Journal)
- (Forker, L. B. and Menzdez, 2001, “An analytical method for benchmarking best peer suppliers” International Journal of Operations and Production Management)
- (Chan, 2003, “Interactive selection model for supplier selection process. An analytical hierarchy process approach”, journal)
- (Khurrum S. Bhutta and Faizul Huq, 2002, “Supplier selection problem: a comparison of the total cost of ownership and analytic hierarchy process approaches, Supply Chain Management”, An International Journal)
- (Markovic, 2010, “Modification of TOPSIS method for solving of multi criteria tasks”, Journal of Operations Research)
- (Liu, J., Ding, F.Y., Lall, V,1998,Using data envelopment analysis to compare suppliers for supplier selection and performance improvement” Supply Chain Management,An International Journal)
- (Garfamy, 2006, A data envelopment analysis approach based on total cost of ownership for supplier selection” Journal of Enterprise Information Management.

- (Siu Ki, 2004, Knowledge-based Customization of Enterprise Systems for Business Process Improvement", Master Thesis)
- (Zhao, K., Yu X. and Wang D, 2009," Study on CBR Supplier Selection Based on Data Mining for Oil Enterprises International Symposium on Information Engineering and Electronic Commerce" Article)
- (Chen, C.T., Lin, C. T., Huang, S. F,2006, "A fuzzy approach for supplier evaluation and in supply chain management", journal)
- (Narasimhan, R, Talluri, S., Mendez, D. ,2001, "Supplier evaluation and rationalization via data envelopment analysis" Journal of Supply Chain Management)
- (Wadhwa, V., Ravindran, A.R, 2007, Vendor selection in outsourcing, Computers and Operations Research" Article)
- (Seydel,2005, "Supporting the paradigm shift in vendor selection", Article)
- (Carter, Ray, 1995 "The seven Cs of effective supplier evaluation. Purchasing and supply management", Journal)
- (Dickson, G.W,2015, An analysis of vendor selection system and decisions. Journal of Purchasing)
- (Johnson, Fraser P, 2011, "Purchasing and supply management" Article)
- (Rogers, Stephen, 2009, The supply-based advantage. How to link suppliers to your organization's corporate strategy", Journal)
- (Microsoft Business, Feb 2018, "Brief explanation of OneDrive for Business", Procedure)
- (University of St Andrews, Jan 2018, OneDrive for Business User Guide, Thesis)

The website references

- (sdggroup,2015, case study of DHL)
- (CNH Industrial, Company Introduction, wiki)
- (CNH Industrial,31/12/2017, ANNUAL REPORT).
- (CNH Industrial, brands, online site)

Internal company documents

- (CNH Industrial, written by Gaetano Bonanno, 23/07/2014, Owned by Massimo Testaquatra, "AQAP")
- (CNH Industrial, written by Riccardo GAY, owned by Vicenzo Russo, 09/06/2015, "Direct sourcin", Procedure)
- (CNH Industrial, Written by Marco Bovo and Luca Ferrari, 16/05/2013, "8 stages", procedure)
- (CNH Industrial level, written by Bonanno Gaetano, 18/07/2014, "Control shipment", procedure)
- (CNH Industrial, written by Riccardo GAY, 09/06/2015, "Resourcing", procedure)
- (CNH Industrial, written by Bonanno Geatano,18/07/2014, "PSA", procedure)
- (CNH Industrial, Quality Bid List rules, 2017, online)

- (CNH Industrial, written by Bonanno Gaetano, 18/07/2014, “Process Audit”, procedure)
- (CNH Industrial, Risk Assessment,2014, Company site)
- (CNH Industrial, written by Bonanno Gaetano, 21/07/2014, Owned by Piero Blunda, “Procedure Process Planning Review”, procedure)
- (CNH Industrial, , 2014, Online, “Global Supplier Scorecard”, procedure)

- (CNH Industrial, written by Bonanno Gaetano, 23 July 2014, “Advanced Product Quality Planning”, procedure)
- (CNH Industrial, written by M.Testquatra, 01/06/2015, “Quality Product Support Process”, procedure)