Chapter 21. Automotive Core Tools

Contents

0) Introduction

The purpose of this chapter is to cover the 5 automotive core tools. However, there can be no in-depth discussion, as it is impossible to cover the 5 core tools in a short chapter. For more information, consult the AIAG Reference manuals on these 5 tools. The 5 core tools are: a) APAP, b) FMEA, c) SPC, d) MSA, e) PPAP. Control Plan is considered part of APAP. The 5 core tools are not neatly discussed in the Standard, but mentioned here and there. Some with fuller discussions such as control plan and MSA. Others are just briefly mentioned such as FMEA, SPC and APAP/PPAP.
At the time of writing, new versions of the core tools are available for upgrading.

1) 8.3.4.4 Product Approval Process (IATF16949)

(Clause Description-Paraphrase)
The organization shall establish, implement, and maintain a product and manufacturing approval process conforming to requirements defined by the customer(s). The organization shall approve externally provided products and services per ISO 9001, Section 8.4.3, prior to submission of their part approval to the customer. The organization shall obtain documented product approval prior to shipment, if required by the customer. Records of such approval shall be retained. NOTE Product approval should be subsequent to the verification of the manufacturing process.

(Highlights of the clause)

- (Ref to old Standards). There was a clause, 7.3.6.3 of the same title, in the old version of ISO/TS16949.
- In the old version it was very simple: conform to a product and manufacturing process approval procedure recognized by the customer. In other words, there is no prescribed method from IATF. PPAP from AIAG can be used but not mandatory.
- The new version uses the form ‘defined’ instead of ‘recognized’ by the customer. The meaning has a slight difference but does not alter the result
- The new version extends the control to sub-supplier. You need to approve externally provided products and services prior to submission of the part approval to the customer
- Records of approval of externally provided products shall be retained
- NOTE said the obvious, only after verification of the manufacturing process, can approval be given.

(Compliance best practice)

8.3.4.4 Product Approval Process

1. *When we speak of design in IATF, we think of the APQP. For submission of data and document to customer, we extract them from APQP files*
2. *But in practice, many organizations do not start with APQP, but will base on PPAP directly for planning and for warrant submission. It saves time, no redundant work, and all the data and rules for approval are given here.*
3. *This is what the clause say, a method initiated by the customer. So you can safely use this method for product and project management. And there is no need to do both APQP and PPAP for the same project.*
4. *For submission, we have to approve info (e.g. ECN, PPAP) etc from sub-suppliers, before onward submission to customer. You should have evidence of this.*
5. *If customer does not specify a method, you can use an internally- defined method for PPAP, complying to the outputs specified in 8.3.5, 8.3.5.1, 8.3.5.2 as applicable. See **Exhibit 21-3.** Otherwise it is an non-compliance.*
6. *For project scheduling, do not use the chart given in **Exhibit 21-1**, as it is only a concept chart used for illustration on APQP. You should just use a Gantt Chart, and lay out your tasks according to sequence. Most importantly, your trial and mass production dates should be based on the master schedule, from the customer*
7. *Inputs from customer are usually drawings and technical specs, and PSW form**.** See **Exhibit 21-2**. This is not sufficient however. You need to ask for master schedule, a PPAP list, and lessons learned, if the part is new to you.*
8. *APQP and PPAP are automotive core tools with a deep level of knowledge. You need to read the AIAG reference manuals or attend such training courses for better understanding.*

2) 7.1.5.1.1 Measurement system analysis (IATF16949)

(Clause Description-Paraphrase)

Statistical studies on the variation present in the results of each type of inspection, measurement, and test equipment system identified in the control plan shall be studied. The analytical methods and acceptance criteria used shall be given in reference manuals. Other analytical methods and acceptance criteria may be used if approved by the customer. Records of customer acceptance of alternative methods shall be retained along with results from alternative measurement systems analysis

(Highlights of the clause)

(Ref to old Standards). This used to be known as 7.6.1 in the previous ISO/TS Standard. The previous requirements are the same as the new one, except for a rewording “reference” to “identified” (in the control plan)

The method used are generally either the AIAG MSA Reference Manual or other equivalents. All equipment identified in the control plan are subject to this study.

NOTE: For MSA studies, critical or special product or process characteristics should be given priority . Some organizations interpret that they only have to check the those equipment used for critical characteristics, which is incorrect.

(Compliance best practice)

7.1.5.1.1 Measurement system analysis

1. *Many organizations provide only GR&R studies instead of the full MSA. A full MSA shall include bias, linearity and stability studies.*
2. *Customer auditor acceptance is common with GR&R. See* ***Exhibit 21-4.*** *There is no specific directive for IATF auditors if GR&R alone is acceptable. In most cases IATF auditor will decide based on customer acceptance.*
3. *However if a customer specified AIAG reference manuals, then G&R is not adequate and the Organization must provide full MSA. For GR&R, attribute characteristics shall use the acceptable methods. This Attribute GR&R study is becoming important as visual and appearance characteristics are getting more emphasis in automotive.* See **Exhibit 21-5.**
4. *There is a NOTE at the bottom of the clause that is creating some confusion. It says "prioritization of MSA should focus on critical or special product or process characteristics". Some organizations interpret this as only equipment used to measure critical characteristics needs MSA. This is wrong, because ALL equipment specified in the control plan shall be provided with MSA studies. The statement just meant that when choosing a point to study a particular measuring equipment for MSA, it should be preferably be a critical point e.g. one that is designated as special characteristics.*

3) 8.3.5.1 D&D Outputs-Supplemental (product) IATF16949

This clause quite a drawn out discussion with lots of details. Refer to Chapter 22 for details.

(Highlight on the clause)

- The purpose for the clause appearing in this chapter is to show DFMEA as part of the output of Product Design
- To understand DMEA, AIAG FMEA Reference Manual should be consulted.

(Compliance best practice)

8.3.5.1 D&D Outputs-Supplemental

1. *This clause is quite a long discussion with lots of details. Refer to Chapter 22 for details. The clause requires DFMEA as the output, which is a core tool. See* ***Exhibit 21-6*** *for a specimen of DFMEA.*
2. *The core team shall be familiar with DFMEA for risk management and PPAP package compilation*
3. *To understand DFMEA, the design team should consult AIAG FMEA Reference Manual, or attend a specific training*

4) 8.3.5.2 Manufacturing Process Design Output (IATF 16949)

This clause quite a drawn out discussion with lots of details. Refer to Chapter 22 for details.

(Highlight on the clause)

- The purpose for the clause appearing in this chapter is to show DFMEA as part of the output of Manufacturing Process Design output.
- To understand PFMEA, AIAG FMEA Reference Manual should be consulted.

(Compliance best practice)

8.*3.5.2 Manufacturing Process Design Output*

4. *This clause quite a long discussion with lots of details. Refer to Chapter 22 for details. The clause requires PFMEA as an output, which is a core tool. See **Exhibit 21-7** for a specimen of PFMEA.*
5. *The core team shall be familiar with PFMEA for risk management and PPAP package compilation*
6. *To understand PFMEA, the design team should refer to AIAG FMEA Reference Manual, or attend a specific training*

5) 8.5.1.1 Control Plan (IATF16949)

(Clause Description-Paraphrase)

The organization shall develop control plans at, subsystem, component, and/or material level for the relevant manufacturing site and all product supplied, including those for processes producing bulk materials as well as parts. Family control plans are acceptable for bulk material and similar parts using a common manufacturing process. The organization shall have a control plan for pre-launch and production that shows linkage and incorporates information from the design risk analysis (if provided by the customer), process flow diagram, and manufacturing process risk analysis outputs (such as FMEA). The organization shall, if required by the customer, provide measurement and conformity data collected during execution of either the pre-launch or production control plans. The organization shall include in the control plan:

a) controls used for the manufacturing process control, including verification of job set-ups;
b) first-off/last-off part validation, as applicable;
c) methods for monitoring of control exercised over special characteristics defined by both the customer and the organization;
d) the customer-required information, if any;
e) specified reaction plan; when nonconforming product is detected, the process becomes statistically unstable or not statistically capable. The organization shall review control plans, and update as required, for any of the following:
f) the organization determines it has shipped nonconforming product to the customer;
g) when any change occurs affecting product, manufacturing process, measurement, logistics, supply sources, production volume changes, or risk analysis (FMEA) ;
h) after a customer complaint and implementation of the associated corrective action, when applicable;
i) at a set frequency based on a risk analysis. If required by the customer, the organization shall obtain customer approval after review or revision of the control plan

(Highlights of the clause)

- (Ref to old Standards). There had been a clause, 7.5.1.1 of the same title.
- Previous requirement were simpler; which is summarized in the main paragraph of the new clause (see above)
- The new requirements are: a), b), d), f) h) and i)
- Details of control plan compilation are now given in the clause description, too many to be transcribed here

- To really able to construct a control plan, AIAG APQP Reference Manual (Control Plan section) should be consulted.

(Compliance best practice)

8.5.1.1 Control Plan

1. *Control Plan, although is a part of APQP Manual, it is widely used for process control by production department.* ***Exhibit 21-8.***
2. *The new requirements on control plan are : a), b), d), f) h) and i) of clause description.*
3. *For new projects, the control plans are expected to comply to this new requirement. Some of the active parts should also be upgraded, because IATF auditors will invariably be using them for production audits*
4. *Verification of set-up is often missed out from Control Plan, and so it should be included back. See* ***Exhibit 21-9***
5. *There is also a need to include alternative or backup process control method in the Control Plan. This is discussed in Clause 8.5.6.1.1 in Chapter 12 & 23. See* ***Exhibit 12-5*** *for a specimen.*

6) 9.1.1.2 Identification of Statistical Tools (IATF16949)

(Clause Description-Paraphrase)

The organization shall determine the appropriate use of statistical tools. The organization shall verify that appropriate statistical tools are included as part of the advanced product quality planning (or equivalent) process and included in the design risk analysis (such as DFMEA) (where applicable), the process risk analysis (such as PFMEA), and the control plan.

(Highlights of the clause)

- (Ref to old Standards). There had been a clause, 8.1.1 identification of statistical tools, in the previous version of ISO/TS1694.
- The requirement was very simple: Appropriate statistical tools for each process shall be determined during advance quality planning and included in the control plan.
- There is basically no change. The full requirement is in the clause description.

(Compliance best practice)

9.1.1.2 Identification of Statistical Tools

1. *SPC is strongly encouraged by IATF especially in the earlier versions of ISO/TS. Like in 6 Sigma, SPC has been toned down somewhat. It is still used for controlling special characteristics. Organization can use it on any characteristic to control its variability.*
2. *The clause requires the organization to identify, during APQP stage, the kind of SPC to be used. Most people regards the XBar/R chart is equivalent to SPC. See* ***Exhibit-21-10****. But this is not true, there are many types of SPC, and XBar/R chart is only one type, and may not be suitable for your case.*
3. *SPC requirement shall be indicated in FMEA, control plan etc*

7) 9.1.1.3 Application of statistical concepts (IATF16949)

(Clause Description-Paraphrase)

Statistical concepts, such as variation, control (stability), process capability, and the consequences of over-adjustment, shall be understood and used by employees involved in the collection, analysis, and management of statistical data.

(Highlights of the clause)

- (Ref to old Standards). There had been a clause, 8.1.2 Knowledge of basic statistical concepts, in the previous version of ISO/TS16949.
- The old requirement was simple: Basic statistical concepts, such as variation, control (stability), process capability and over-adjustment shall be understood and utilized throughout the organization.
- Instead of throughout the organization, the new clause only requires relevant people to be understand. These are people involved in the collection, analysis, and management of statistical data. It is more practical

(Compliance best practice)

9.1.1.3 Application of statistical concepts

1. *In particular, organization must ensure the relevant people have the knowledge to construct/interpret the SPC charts correctly*
2. *Training on SPC is useful to ensure compliance. The training shall cover variation control, process capability and over-adjustments.*
3. *IATF auditors will know your level of competency on SPC, by looking at the charts you have produced.*

8) SIs & FAQs

FAQ	IATF Clause	Questions and Answers
6	**7.1.5.1.1 Measurement system analysis**	**QUESTION:** **Are MSA studies required for each instrument or device?** **ANSWER:** No. A complete statistical study on each single piece of equipment is not required. Instruments with the same characteristics (e.g. measurement range, resolution, repeatability, etc.) can be grouped and a sample instrument (representative of the gauge family) can be used for the statistical study.

9) Supplementary Notes

Legend: HOC= Highlights of Clause, CBP= Compliance Best Practice, S&Q= SIs & FAQ, EXH= Exhibits

Clause	Section	Clarification Subjects
8.3.4.4	CBP	**SN21.1. If the PPAP list from customer is too simple, and does not including mandatory items in the clauses e.g MSA and SPC. Do I still have to do these missing items?**
8.3.5.1	CBP	**SN21.2. Am I allowed to change the FMEA format?**
8.5.1.1	CBP	**SN21.3. Why is Control Plan not a core tool by itself, but part of APQP?**

8.5.1.1	CBP	**SN21.4. Am I allowed to change the Control Plan format? Can I call it something else e.g. Process Management Plan, to avoid being confuse with control charts by the people?**
7.1.5.1.1	CBP	**SN21.5. For attribute GR&R, there are a lot of visual defects. Do we have to do one at a time, or I can do all at one time?**
9.1.1.2	CBP	**SN21.6. Customer asked for SPC only during PPAP submission, but did not say we need to do so during mass production. Do we need to include it in in our operations?**
9.1.1.3	CBP	**SN21.7 Some automotive parts are only running few days in a month. When we compile the monthly studies on CpK, we find the results looking odd. What is wrong?**

SN21.1. If the PPAP list from customer is too simple, and does not including mandatory items in the clauses e.g. MSA and SPC. Do I still have to do these missing items?

If it is a mandatory item in the clause, you have to produce it. You need not send the results to the customer, but you have to retain the records for IATF audit.

SN21.2. Am I allowed to change the FMEA format?

Yes, you can, but not advisable. Firstly the form is already very cramp, adding more columns will make it worse. Secondly it is well-proven to contain adequate information. I am not sure what else you can bring to the form that is not already there.

SN21.3. Why is Control Plan not a core tool by itself, but part of APQP?

Control Plan is contained in the APQP reference manual, which I also don't quite agree. It is so important that it should be the 6th core tool. All the more now that control plan is used so widely in this new version. It has also shifted from design zone to production/process control zone (Clause 8.3 to 8.5). But it does not really matter, you can always consider it as a separate tool. I always do.

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SN21.4. Am I allowed to change the Control Plan format? Can I call it something else e.g. Process Management Plan, to avoid being confuse with control charts by the people?

Yes, you can change the format but not recommended. It is well established. If you change the format, it will be in the way of usage and reference. Yes, you can change the name of the tool. There are some organizations doing it. Its OK with IATF auditors.

SN21.5. For attribute GR&R, there are a lot of visual defects. Do we have to do one at a time, or can I do all at one time?

You can do all at one time. There are enough samples used (50), for you to plant in all sort of appearance defective parts for the study. Organize it well and you can get the same results.

SN21.6. Customer asked for SPC only during PPAP submission, but did not say we need to do so during mass production. Do we need to include it in in our operations?

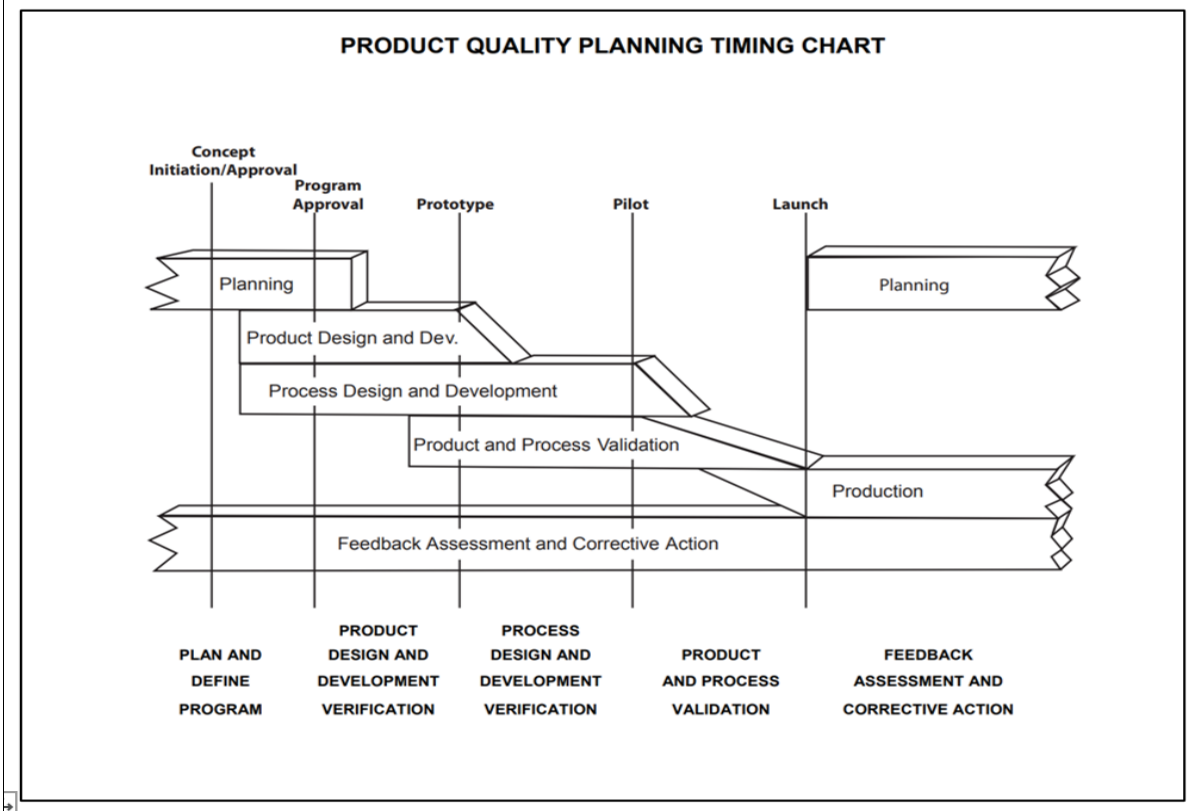
It is quite unlikely customers would not ask for SPC on special characteristics. You should recheck their SQM or reconfirm with them. But if it is really not needed, ask for a written confirmation and you can be exempted.

SN21.7. Some automotive parts are only running few days in a month. When we compile the monthly studies on CpK, we find the results looking odd. What is wrong?

SPC (Xbar/R) has to work with min 100 data to be accurate. If you do not have the samples in a month, extend it further, to say 3 months, or even 6 months. It is better to not to have results every month, than to have inaccurate results. Alternatively, you can run on a cumulative, or moving SPC, so that you can still have monthly data. However, some software has a limit on total data they can process.

10) Exhibits

Exhibit 21-1. APQP



Remarks given in this section explain on the exhibit. Do not include them as part of the form.

- This is only a conceptual chart that shows the process is roughly divided into 5 phases and also their sequence. It is only a concept. You are not required to show linkage of your actual project plan to this APQP chart
- Using a Gantt Chart is more effective because all customers use that. Lay out all the PPAP items in sequence and provide timing for their execution.
- Most importantly is to follow the customer's timing, especially for the first trial and mass production.

Exhibit 21-2. PSW 600 Form

DAIMLERCHRYSLER Ford GM

Part Submission Warrant

Part Name _____ Cust. Part Number _____

Shown on Drawing No. _____ Org. Part Number _____

Engineering Change Level _____ Dated _____

Additional Engineering Changes _____ Dated _____

Safety and/or Government Regulation ☐ Yes ☐ No Purchase Order No. _____ Weight (kg) _____

Checking Aid No. _____ Checking Aid Engineering Change Level _____ Dated _____

ORGANIZATION MANUFACTURING INFORMATION

Organization Name & Supplier/Vendor Code

Street Address

City Region Postal Code Country

CUSTOMER SUBMITTAL INFORMATION

Customer Name/Division

Buyer/Buyer Code

Application

MATERIALS REPORTING

Has customer-required Substances of Concern information been reported? ☐ Yes ☐ No ☐ n/a

Submitted by IMDS or other customer format: _____

Are polymeric parts identified with appropriate ISO marking codes? ☐ Yes ☐ No ☐ n/a

REASON FOR SUBMISSION (Check at least one)

- ☐ Initial Submission
- ☐ Engineering Change(s)
- ☐ Tooling: Transfer, Replacement, Refurbishment, or additional
- ☐ Correction of Discrepancy
- ☐ Tooling Inactive > than 1 year
- ☐ Change to Optional Construction or Material
- ☐ Supplier or Material Source Change
- ☐ Change in Part Processing
- ☐ Parts Produced at Additional Location
- ☐ Other – please specify below

REQUESTED SUBMISSION LEVEL (Check one)

- ☐ Level 1 – Warrant only (and for designated appearance items, an Appearance Approval Report) submitted to customer.
- ☐ Level 2 – Warrant with product samples and limited supporting data submitted to customer.
- ☐ Level 3 – Warrant with product samples and complete supporting data submitted to customer.
- ☐ Level 4 – Warrant and other requirements as defined by customer.
- ☐ Level 5 – Warrant with product samples and complete supporting data reviewed at organization's manufacturing location.

SUBMISSION RESULTS

The results for ☐ dimensional measurements ☐ material and functional tests ☐ appearance criteria ☐ statistical process package

These results meet all design record requirements: ☐ Yes ☐ NO (If "NO" – Explanation Required)

Mold / Cavity / Production Process _____

DECLARATION

I affirm that the samples represented by this warrent are representative of our parts which were made by a process that meets all Production Part Approval Process Manual 4th Edition Requirements. I further affirm that these samples were produced at the production rate of ____ /__hours. I also certify that documented evidence of such compliance is on file and available for review. I have noted any deviations from this declaration below.

EXPLANATION/COMMENTS: _____

Is each Customer Tool properly tagged and numbered? ☐ Yes ☐ No ☐ n/a

Organization Authorized Signature _____ Date _____

Print Name _____ Phone No. _____ FAX No. _____

Title _____ E-mail _____

FOR CUSTOMER USE ONLY (IF APPLICABLE)

PPAP Warrant Disposition: ☐ Approved ☐ Rejected ☐ Other _____

Customer Signature _____ Date _____

Print Name _____ Customer Tracking Number (optional) _____

Remarks given here explain on the exhibit. Do not include them as part of the document.

- This PSW form was originally a creation of AIAG, to specify what is needed for project submission for the 3 automotive companies in US. The level of submission tells you what is needed. But this is not really so useful, when it is opened to the world. Different OEM in Europe and Japan do not follow this exactly. It can still be used, but the information provided in PSW is not quite enough to start planning.
- European, Japanese, Koreans and Chinese OEM require more or different things. You need to ask from your customers accordingly e.g. master schedule, PPAP list, lessons learned if applicable.

Exhibit 21-3. PPAP Requirement

PPAP List

1. Design Records
A copy of the drawing. If the customer is responsible for designing, this is a copy of customer drawing that is sent together with the Purchase Order (PO). If supplier is responsible for designing this is a released drawing in supplier's release system.

2. Authorized Engineering Change Documents
A document that shows the detailed description of the change. Usually this document is called "Engineering Change Notice", but it may be covered by the customer PO or any other engineering authorization.

3. Customer Engineering Approval, if required
This approval is usually the Engineering trial with production parts performed at the customer plant. A "temporary deviation" usually is required to send parts to customer before PPAP. Customer may require other "Engineering Approvals".

4. Design Failure Modes and Effects Analysis (DFMEA), applied in special situations
A copy of the Design Failure Mode and Effect Analysis (DFMEA), reviewed and signed-off by supplier and customer.

5. Process Flow Diagram
A copy of the Process Flow, indicating all steps and sequence in the fabrication process, including incoming components.

6. Process Failure Modes and Effects Analysis (PFMEA)
A copy of the Process Failure Mode and Effect Analysis (PFMEA), reviewed and signed-off by supplier and customer. The PFMEA follows the Process Flow steps, and indicate "what could go wrong" during the fabrication and assembly of each component.

7. Control Plan
A copy of the Control Plan, reviewed and signed-off by supplier and customer. The Control Plan follows the PFMEA steps, and provides more details on how the "potential issues" are checked in the incoming quality, assembly process or during inspections of finished products.

8. Measurement System Analysis (MSA)
MSA usually contains the Gage R&R for the critical or high impact characteristics, and a confirmation that gauges used to measure these characteristics are calibrated.

9. Dimensional Results
A list of every dimension noted on the ballooned drawing. This list shows the product characteristic, specification, the measurement results and the assessment showing if this dimension is "ok" or "not ok". Usually a minimum of 6 pieces is reported per product/process combination.

10. Records of Material / Performance Test Results
A summary of every test performed on the part. This summary is usually on a form of DVP&R (Design Verification Plan and Report), which lists each individual test, when it was performed, the specification, results and the assessment pass/fail. If there is an Engineering Specification, usually it is noted on the print. The DVP&R shall be reviewed and signed off by both customer and supplier engineering groups. The quality engineer will look for a customer signature on this document. In addition, this section lists all material certifications (steel, plastics, plating, etc.), as specified on the print. The material certification shall show compliance to the specific call on the print.

11. Initial Process Studies
Usually this section shows all Statistical Process Control charts affecting the most critical characteristics. The intent is to demonstrate that critical processes have stable variability and that is running near the intended nominal value.

12. Qualified Laboratory Documentation
Copy of all laboratory certifications of the laboratories that performed the tests reported on section 10.

13. Appearance Approval Report (AAR)
A copy of the AAI (Appearance Approval Inspection) form signed by the customer. Applicable for components affecting appearance only.

14. Sample Production Parts
A sample from the same lot of initial production run. The PPAP package usually shows a picture of the sample and where it is kept (customer or supplier).

15. Master Sample
A sample signed off by customer and supplier, that usually is used to train operators on subjective inspections.

16. Checking Aids
When there are special tools for checking parts, this section shows a picture of the tool and calibration records, including dimensional report of the tool.

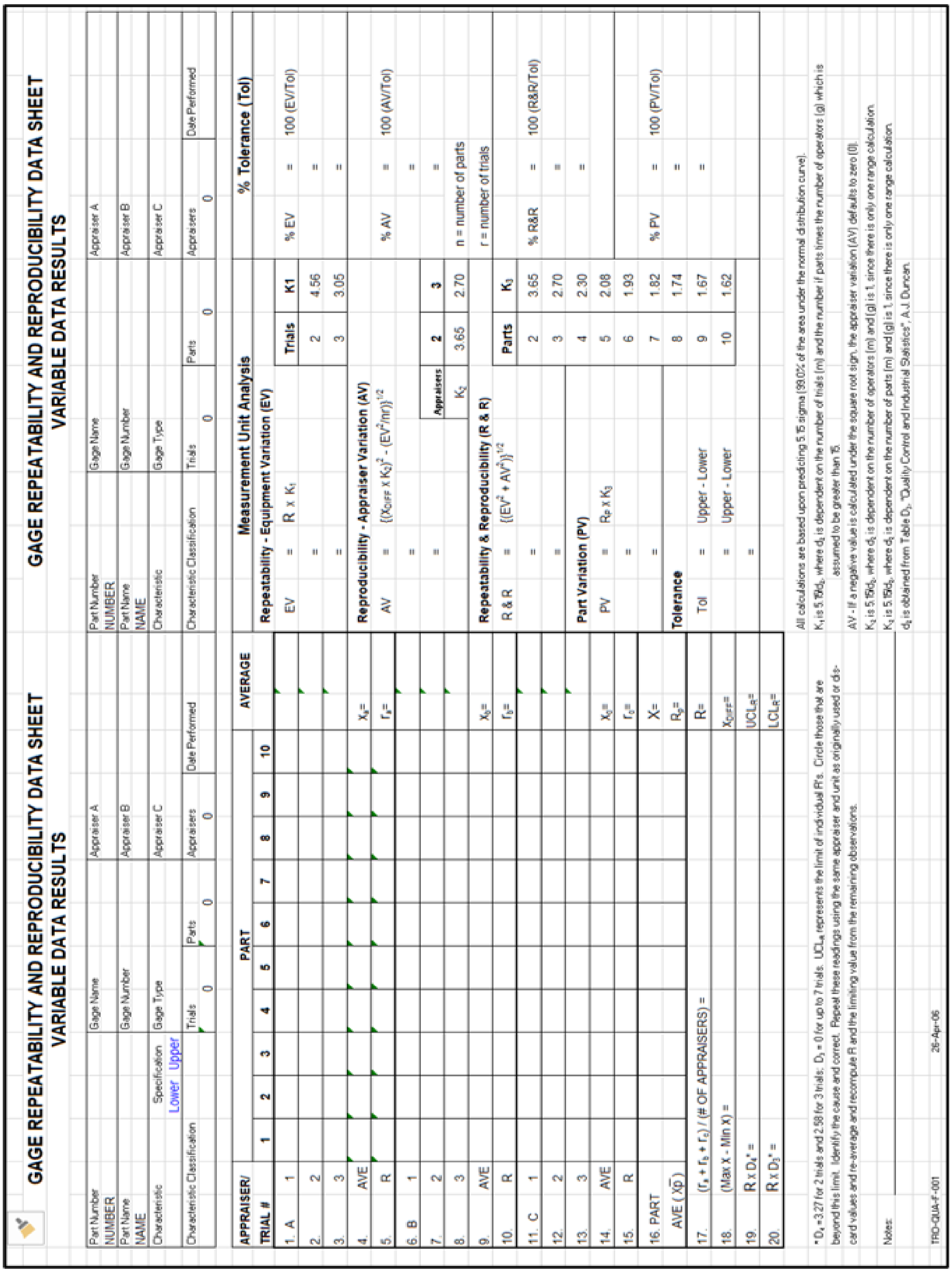
17. Customer-Specific Requirements
Each customer may have specific requirements to be included on the PPAP package. North America auto makers OEM (Original Equipment Manufacturer) requirements are listed on the IATF website.

18. Part Submission Warrant (PSW)
This is the form that summarizes the whole PPAP package. This form shows the reason for submission (design change, annual revalidation, etc.) and the level of documents submitted to the customer. There is a section that asks for "results meeting all drawing and specification requirements: yes/no" refers to the whole package.

Remarks given in this section explain on the exhibit. Do not include them as part of the document

- This list is taken from the internet and it has 18 elements. Most large OEM will ask for more, or something different. You have to follow customer requirement
- In the event you are dealing with smaller customers, and quite commonly they do not have a PPAP list, You can follow this list, or a modified one from this list, as your internal standard

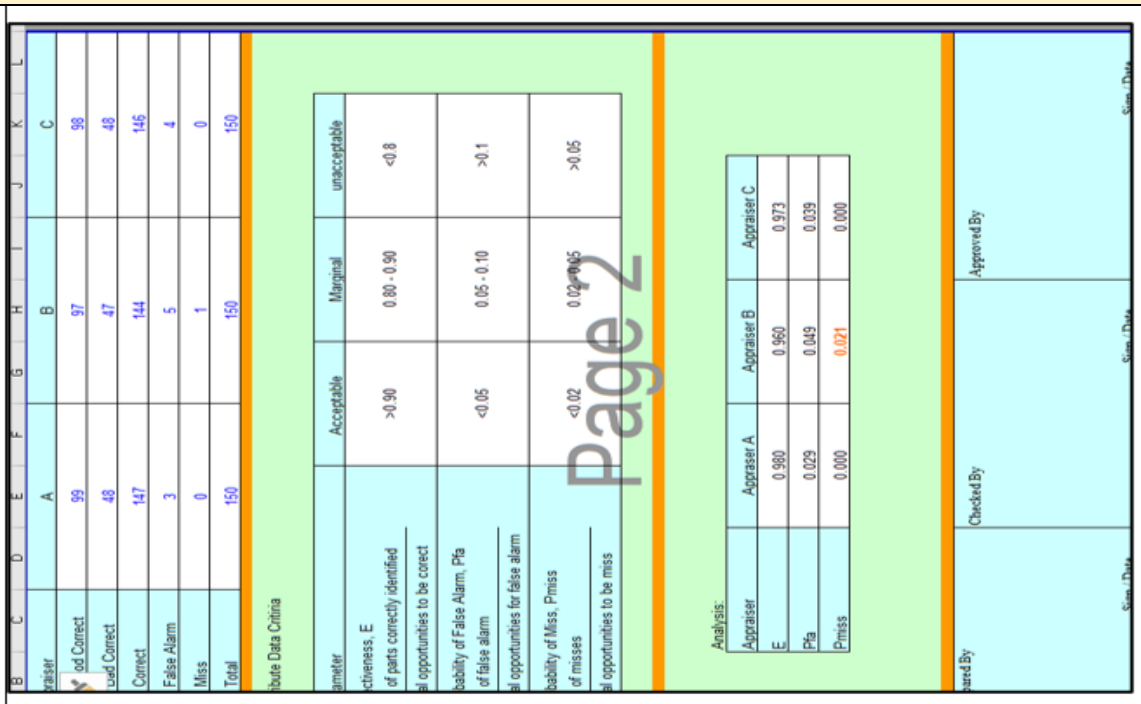
Exhibit 21-4. GR&R



Remarks given in this section explain on the exhibit. Do not include them as part of the document

- This is often taken as MSA. It is not, as It is only part of an MSA. A full MSA will be GR&R + Linearity, stability and bias studies.
- Generally, IATF auditors will accept, if the customer did not specify to follow AIAG. If they do, that GR&R is not enough and therefore it is a nonconformance.
- Quite commonly, North American customers specify AIAG. So you need to read through their SQM carefully. Japanese, European and other Asian OEM tend to accept GR&R, in place of MSA.
- It is also common to see slight variations of the above. Organization often claims it is from customers or downloaded from the internet, that generated erroneous results. Under such circumstances, it is recommended that you cross check the results using the AIAG format.

Exhibit 21-5. Attribute GR&R



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	A	B	C
od Correct	99	97	98
ued Correct	48	47	48
Correct	147	144	146
False Alarm	3	5	4
Miss	0	1	0
Total	150	150	150

ibute Data Criteria

ameter	Acceptable	Marginal	unacceptable
ctiveness, E of parts correctly identified al opportunities to be corect	>0.90	0.80 - 0.90	<0.8
bability of False Alarm, Pfa of false alarm al opportunities for false alarm	<0.05	0.05 - 0.10	>0.1
bability of Miss, Pmiss of misses al opportunities to be miss	<0.02	0.02 - 0.05	>0.05

Analysis:

Appraiser	Appraiser A	Appraiser B	Appraiser C
E	0.980	0.960	0.973
Pfa	0.029	0.049	0.039
Pmiss	0.000	0.021	0.000

pared By | Checked By | Approved By

Page 1

Gage Repeatability & Reproducibility

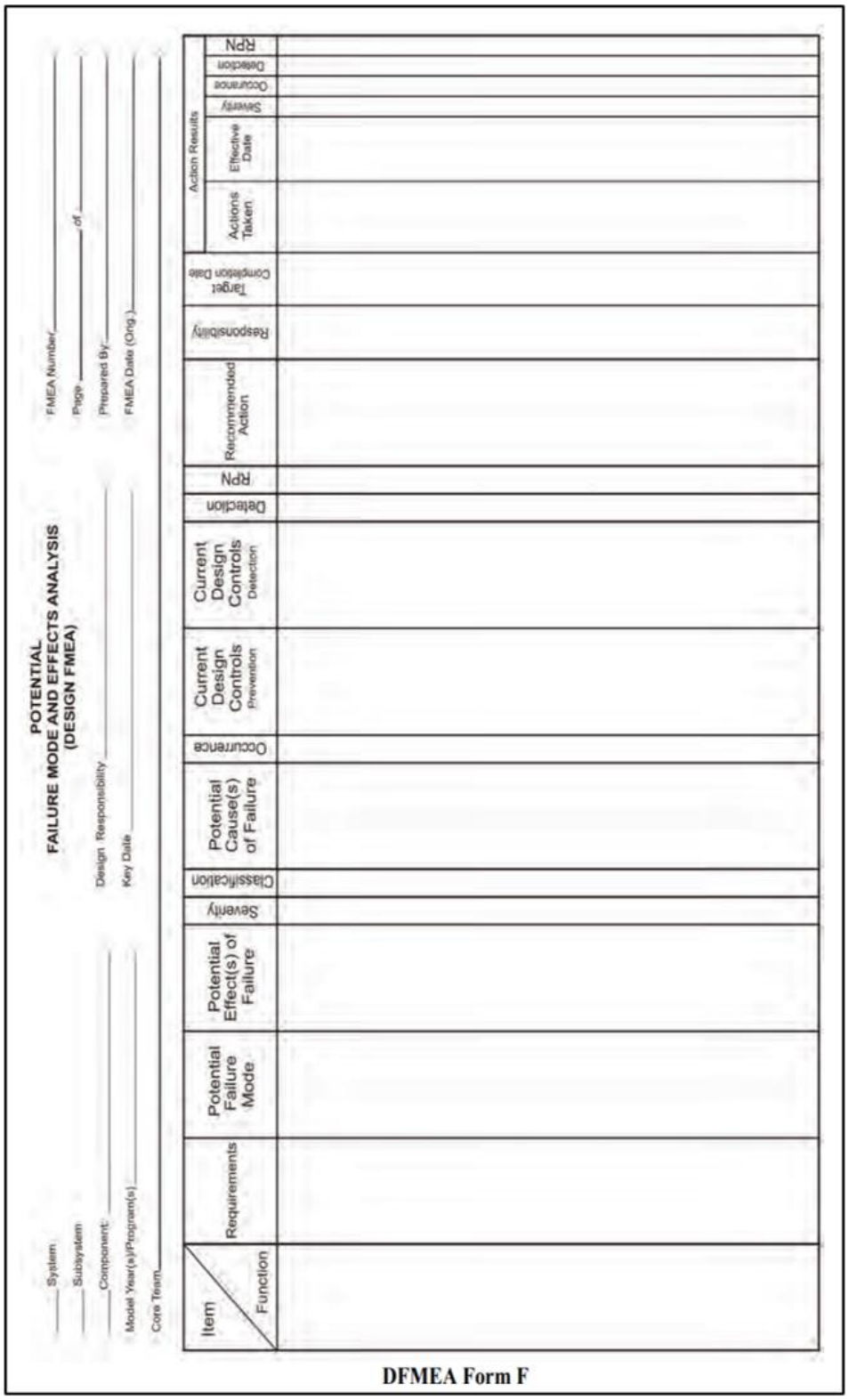
GAGE NAME AND IDENTIFICATION	VISUAL INSPECTION	PART NAME :	XY2 100
		CHARACTERISTIC MEASURED :	Visual Defects
DESIGN		TOTAL NO. OF ACCEPTS	34
		REPORT DATE :	11-Jan-2019
NUMBER OF APPRAISERS	= 3	TOTAL NO. OF REJECTS	16
NUMBER OF PARTS	= 50	CONTROL NUMBER :	
NUMBER OF TRIALS	= 3		

Assembly	A/R	A 1	A 2	A 3	B 1	B 2	B 3	C 1	C 2	C 3
1	A	A	A	A	A	A	A	A	A	A
2	A	A	A	A	A	A	A	A	A	A
3	R	R	R	R	R	R	R	R	R	R
4	R	R	R	R	R	R	R	R	R	R
5	R	R	R	R	R	R	R	R	R	R
6	A	A	A	A	A	A	A	R	A	A
7	A	A	A	A	A	A	A	A	A	A
8	A	A	A	A	A	R	A	A	A	A
9	R	R	R	R	R	R	R	R	R	R
10	A	A	A	A	A	A	A	A	A	A
11	A	A	A	R	A	A	A	A	R	A
12	R	R	R	R	R	R	R	R	R	R
13	A	A	A	A	A	A	A	A	A	A
14	A	A	A	A	A	A	A	A	A	A
15	A	A	A	A	A	A	A	A	A	A
16	A	A	A	A	A	R	A	R	A	A
17	A	A	A	A	A	A	A	A	A	A
18	A	A	A	A	A	A	R	A	A	A
19	A	A	A	R	A	A	A	A	R	A
20	A	A	A	A	A	A	A	A	A	A
21	A	A	A	A	A	R	A	A	A	A
22	R	R	R	R	R	R	R	R	R	R
23	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	A	A	A	A	A
25	R	R	R	R	R	R	R	R	R	R
26	R	R	R	R	R	R	R	R	R	R
27	A	A	A	A	A	A	A	A	A	A
28	A	A	A	A	A	R	A	A	A	A
29	A	A	A	A	A	A	A	A	A	A
30	R	R	R	R	R	R	R	R	R	R
31	A	A	A	A	A	A	A	A	A	A
32	A	A	A	A	A	A	A	A	A	A
33	A	A	A	A	A	A	A	A	A	A
34	R	R	R	R	R	R	R	R	R	R
35	A	A	A	A	A	A	A	A	A	A
36	A	A	A	A	A	A	A	A	A	A
37	R	R	R	R	R	R	R	R	R	R
38	A	A	A	A	A	A	A	A	A	A
39	R	R	R	R	R	R	R	R	R	R
40	A	A	A	A	A	A	A	A	A	A
41	A	A	A	A	A	A	A	A	A	A
42	R	R	R	R	R	R	R	R	R	R
43	A	A	A	A	A	A	A	A	A	A
44	A	A	A	A	A	A	A	A	A	A
45	R	R	R	R	R	R	R	R	R	R
46	A	A	A	A	A	A	A	A	A	A
47	A	A	A	A	A	A	A	A	A	A
48	R	R	R	R	R	R	R	R	R	R
49	A	A	A	A	A	A	A	A	A	A
50	R	R	R	R	R	R	R	R	R	R

Remarks given in this section explain on the exhibit. Do not include them as part of the document

- Attribute GR&R is a modified GR&R for studying of 'yes/no', 'OK/Not OK' type of measurement systems
- The above is the long method which is acceptable to AIAG. Earlier on there is a short method, which is not in use now
- Alternatively, you can also use software such as Minitab. Minitab's presentation is totally different and you need to go through their tutorial to understanding and interpret
- For more details, consult the AIAG MSA Reference Manual

Exhibit 21-6 DMEA Form



Remarks given in this section explain on the exhibit. Do not include them as part of the document

- DFMEA form was introduced by AIAG to standardize presentation of product risks by suppliers.
- This one is slightly different from the PFMEA, but many people did not notice. The difference is in the prevention and detection columns. So the 2 forms are not interchangeable

Exhibit 21-7 PMEA Form

PFMEA Form A

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(PROCESS FMEA)

Item: _____ Process Responsibility _____ FMEA Number _____

Model Year(s)/Program(s) _____ Key Date _____ Page _____ of _____

Core Team _____ Prepared By: _____

FMEA Date (Orig.) _____

Process Step / Function / Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Cause(s) of Failure	Occurrence	Current Process Controls	Current Process Controls	Detection	RPN	Recommended Action	Responsibility & Target Completion Date	Action Results				
													Actions Taken & Effective Date	Severity	Occurance	Detection	RPN

Remarks given in this section explain on the exhibit. Do not include them as part of the form.

- PFMEA form was introduced by AIAG to standardize presentation by suppliers on manufacturing process risks.
- Note that there are some small differences between DFMEA and PFMEA. Make sure you are using the correct form
- There are some changes between the current format and the previous one. So if you are still using the old one, you should change over gradually

Exhibit 21-8 Control Plan

CONTROL PLAN

☐ Prototype ☐ Pre-Launch ☑ Production

Page 1 of 1

Control Plan Number: 1240	Key Contact/Phone: A. P. Smith 313-472-0001	Date (Orig.): 9/9/2007	Date (Rev.): 2/4/2008
Part Number/Latest Change Level: 32123345 F	Core Team: See attached list	Customer Engineering Approval/Date (If Req'd.)	
Part Name/Description: I/P Clip (Plastic)	Organization/Plant Approval/Date	Customer Quality Approval/Date (If Req'd.)	
Organization/Plant: Alm Plastic Co., Iowa Plant; Organization Code: 34567J	Other Approval/Date (If Req'd.)	Other Approval/Date (If Req'd.)	

PART/ PROCESS NUMBER	PROCESS NAME/ OPERATION DESCRIPTION	MACHINE, DEVICE, JIG, TOOLS FOR MFG.	CHARACTERISTICS			SPECIAL CHAR. CLASS	METHODS					REACTION PLAN
			NO.	PRODUCT	PROCESS		PRODUCT/PROCESS SPECIFICATION/ TOLERANCE	EVALUATION/ MEASUREMENT TECHNIQUE	SAMPLE SIZE	SAMPLE FREQ.	CONTROL METHOD	
8	Injected mold plastic parts	Injection mold machine #22	12		Raw material (pellet dryer)		1% max. rel. humidity	Humidity gage on dryer	1	hour	Record sheet	Adjust dryer, dry material and requalify

EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Remarks given in this section explain on the exhibit. Do not include them as part of the document

- This is the control plan recommended by AIAG, but it is not mandatory.
- Many Japanese OEM do not follow this. They tend to have one with product control on one side, and process control on another side of the form.
- If you are using this, try to link up the steps with FMEA, so the risk management can be seen clearer. You can do that by having a reference no for each step.

Exhibit 21-9 Showing Setup in Control Plan

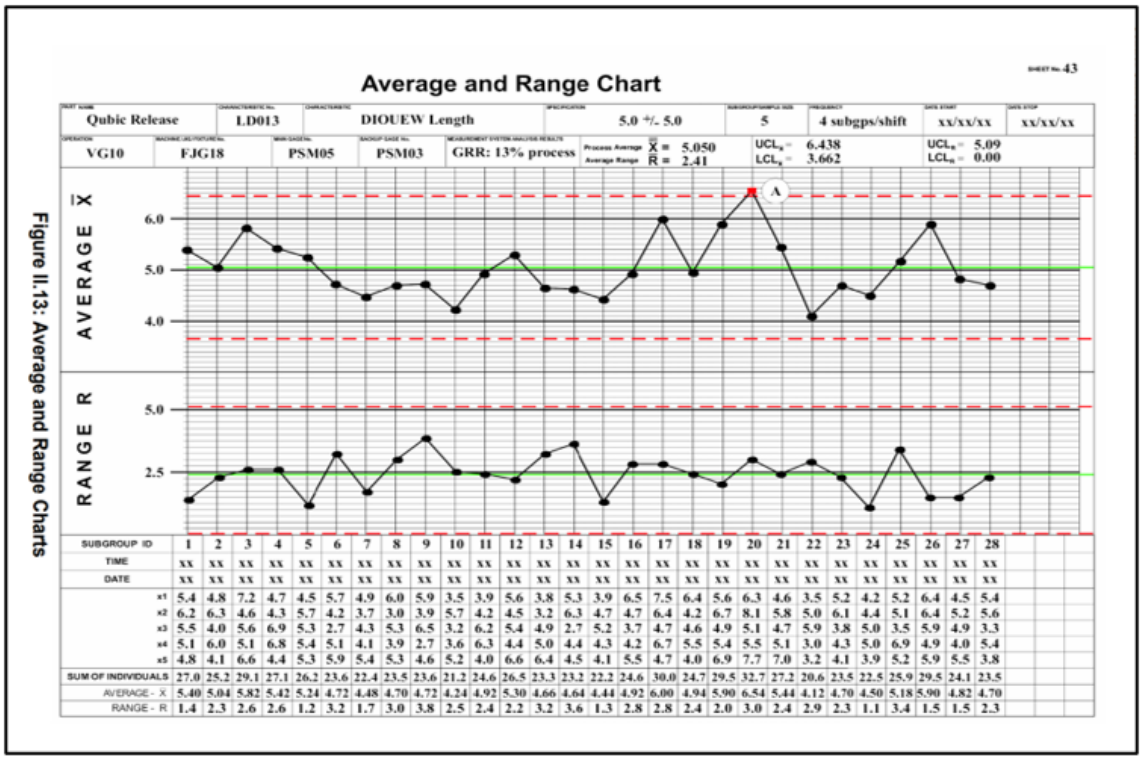
CONTROL PLAN (Molding)

Customer Name:	Beyonics		Part Name:	Lower Case (M1)					Part No.	BLA2SC00562A	
Process Flow		Machine, Device, Jig Tools for Manufacturing	Special/Char. Class Designation	Characteristics			Methods				Reaction Plan if Out of Control Conditions are Encountered
Process No.	Process Name			Print Ref. No.	Process Parameter	Product Characteristic	Product/Process Specification / Tolerance	Measurement Technique	Sample Size	Sample Freq.	Analysis Method	
1	Material Issuance to Production	n/a			n/a	n/a	PC XXXX	Visual	100%	every request	Material Request Form	Return to Store
2a	Material Preheating	Hopper Dryer	M			Temp / Time	90 ~ 100 C / 3~4 hrs	Timer / Thermo Controller		Setup / 4-hourly	* Mold Setup Form * Daily Mc Inspection Checklist	Adjust / Recheck
2b	Machine Setup	Injection Molding Mc SC120 ton				Temperature	Nozzle : 280 ~ 300 C Front : 280 ~ 300 C Middle : 275 ~ 295 C Rear : 260 ~ 280 C	Temperature Indicative		Setup / 4-hourly	* Mold Setup Form * Daily Mc Inspection	Adjust / Recheck
3	Sampling and Setup Inspection		M KPC			Appearance / Fitting Dimension	As per Inspection Instruction See Inspection Instruction for Specs.	Visual Inspection 1st piece buy-off TMS/Caliper	1 shot 1 shot	Setup Setup	Compare with Approved Samples Drawings / FAI / Data Sheet	Adjust / Recheck Adjust / Recheck
4	Mass Prodcution WIP	Injection Molding Mc SC 120 ton				Appearance Pressure Injection Cycle Time	As per I.I. 75 ~ 95 % 5.0 ~ 8.0 sec 40 ~ 45 sec	Visual Mc Actual Values / Gauges	1 shot	Continuous every 4 hrs	Approved / Limit Samples Daily Mc Inspection List / Molding Mc Parameter	Adjust / Recheck
5	In-Process Inspection (IPQC)		KPC			Appearance Dimension	As Per Inspection Instruction	Visual TMS / Caliper	1 shot	every 2 hrs every shift	Data Sheet X-bar R-Chart Cpk Analysis	Adjust / Recheck

Remarks given in this section explain on the exhibit. Do not include them as part of the document

- Setup verification is now a requirement and the step shall be written on the control plan. This is given in the red-framed line
- First-off verification is generally the validation of the setup, it is given in the blue-framed line
- In practice, the two go hand-in-hand and both are needed to be shown

Exhibit 21-10 SPC



Average and Range Chart

Qubic Release	LD013	DIOUEW Length	5.0 +/- 5.0	5	4 subgps/shift	xx/xx/xx	xx/xx/xx																			
VG10	FJG18	PSM05	PSM03	GRR: 13% process	$\bar{\bar{X}}$ = 5.050	$\bar{R}$ = 2.41	$UCL_{\bar{X}}$ = 6.438	$LCL_{\bar{X}}$ = 3.662	UCL_R = 5.09	LCL_R = 0.00																
SUBGROUP ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
TIME	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
DATE	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
x1	5.4	4.8	7.2	4.7	4.5	5.7	4.9	6.0	5.9	3.5	3.9	5.6	3.8	5.3	3.9	6.5	7.5	6.4	5.6	6.3	4.6	3.5	5.2	4.2	5.2	6.4	4.5	5.4
x2	6.2	6.3	4.6	4.3	5.7	4.2	3.7	3.0	3.9	5.7	4.2	4.5	3.2	6.3	4.7	4.7	6.4	4.2	6.7	8.1	5.8	5.0	6.1	4.4	5.1	6.4	5.2	5.6
x3	5.5	4.0	5.6	6.9	5.3	2.7	4.3	5.3	6.5	3.2	6.2	5.4	4.9	2.7	5.2	3.7	4.7	4.6	4.9	5.1	4.7	5.9	3.8	5.0	3.5	5.9	4.9	3.3
x4	5.1	6.0	5.1	6.8	5.4	5.1	4.1	3.9	2.7	3.6	6.3	4.4	5.0	4.4	4.3	4.2	6.7	5.5	5.4	5.5	5.1	3.0	4.3	5.0	6.9	4.9	4.0	5.4
x5	4.8	4.1	6.6	4.4	5.3	5.9	5.4	5.3	4.6	5.2	4.0	6.6	6.4	4.5	4.1	5.5	4.7	4.0	6.9	7.7	7.0	3.2	4.1	3.9	5.2	5.9	5.5	3.8
SUM OF INDIVIDUALS	27.0	25.2	29.1	27.1	26.2	23.6	22.4	23.5	23.6	21.2	24.6	26.5	23.3	23.2	22.2	24.6	30.0	24.7	29.5	32.7	27.2	20.6	23.5	22.5	25.9	29.5	24.1	23.5
AVERAGE - X	5.40	5.04	5.82	5.42	5.24	4.72	4.48	4.70	4.72	4.24	4.92	5.30	4.66	4.64	4.44	4.92	6.00	4.94	5.90	6.54	5.44	4.12	4.70	4.50	5.18	5.90	4.82	4.70
RANGE - R	1.4	2.3	2.6	2.6	1.2	3.2	1.7	3.0	3.8	2.5	2.4	2.2	3.2	3.6	1.3	2.8	2.8	2.4	2.0	3.0	2.4	2.9	2.3	1.1	3.4	1.5	1.5	2.3

Figure II.13: Average and Range Charts

Remarks given in this section explain on the exhibit. Do not include them as part of the document

- This is a Xbar/R chart. Many people think that this is SPC. Yes, it is one of the SPC methods. There are others. Example: within Average-Range charts, there are other variation e.g. Xbar/S, IMR charts, Median & Range charts. There are also other forms of charts such as P chart, C chart and U chart etc.
- In most situation, Xbar/R chart is suitable. Note that this particular chart only show the graph. Most software now calculate the process capability (CPK, PPK etc) as well. Choose a chart that also give the process capability data and you can kill 2 birds with 1 stone.
- Besides the CpK, it is important to understand the Xbar/R chart because it gives warnings on upcoming problems. Actions can then be taken before problem hits you. You do this by studying the curves. You need to attend a SPC course or read up the SPC reference manual to understand

>> End of Chapter 21 <<