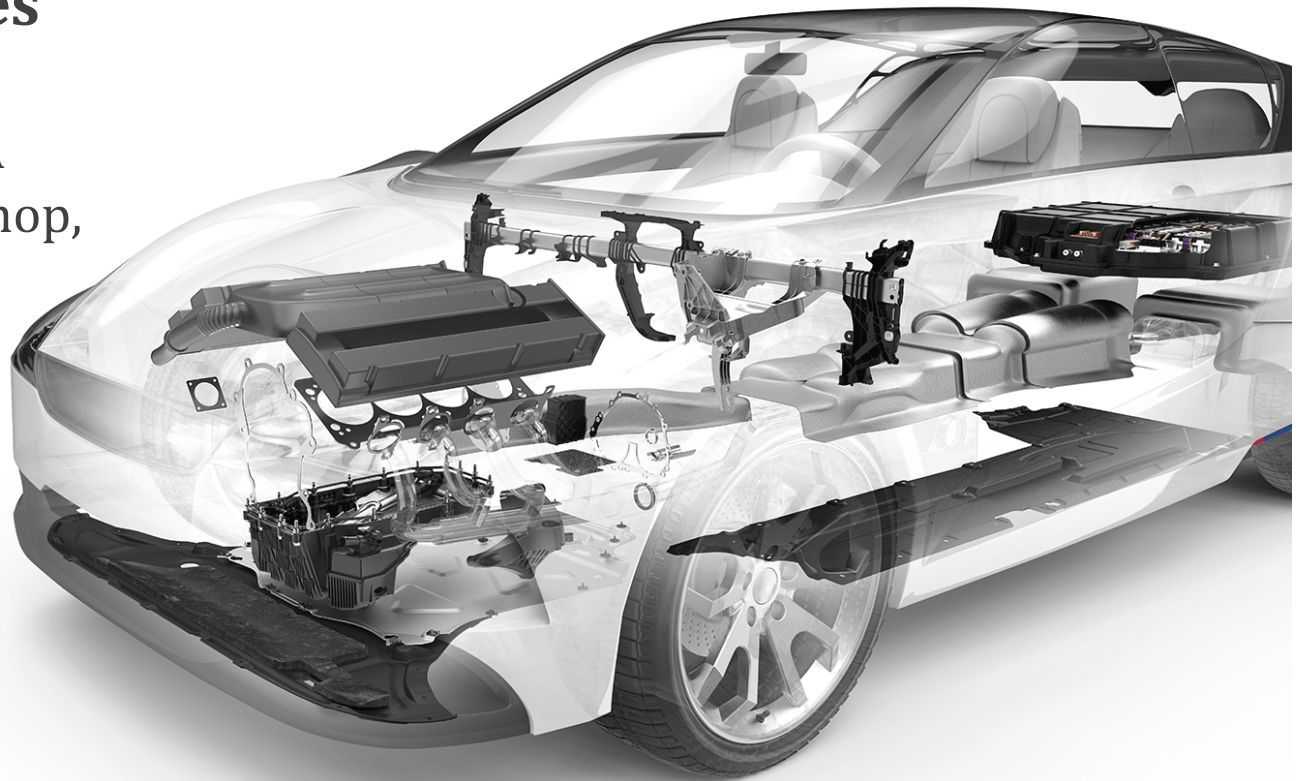


ElringKlinger

PEMFC Technology; Stack manufacturing processes and quality techniques

PEMFC stack and MEA
manufacturing workshop,
October 11th 2018,
Brussels



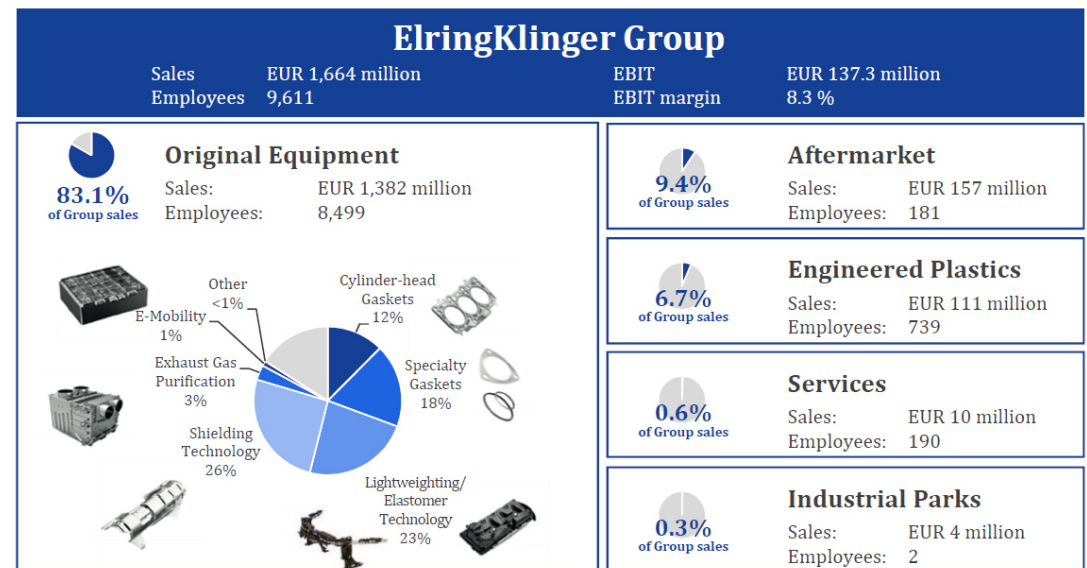
Agenda

- ElringKlinger at a glance
- ElringKlinger PEMFC Products
- Market situation
- PEMFC manufacturing Technology at ElringKlinger
- Manufacturing and quality processes



Company profile

- 47 facilities worldwide, Turnover 2017: 1.664 billion €, 10.000 employees,
- family as strong anchor shareholder, 52 %
- Focus on mass production of parts for the automotive industry
- Supplier of virtually every OEM in the world
→ familiar with all quality requirements and certifications required
- Committed to play leading role in the switch to alternative drivetrains, fuel cell and battery activities



All figures refer to FY 2017

Divisions



Cylinder-head gaskets



Sealing systems



Plastic housing modules



Lightweight plastic components



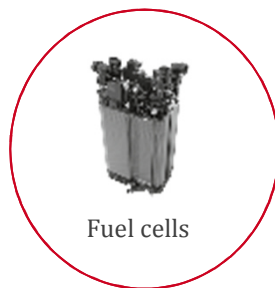
Shielding systems



Aftermarket



Battery technology



Fuel cells



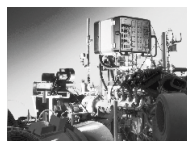
Electric drive unit



Development services with hofer powertrain



Engineered plastics

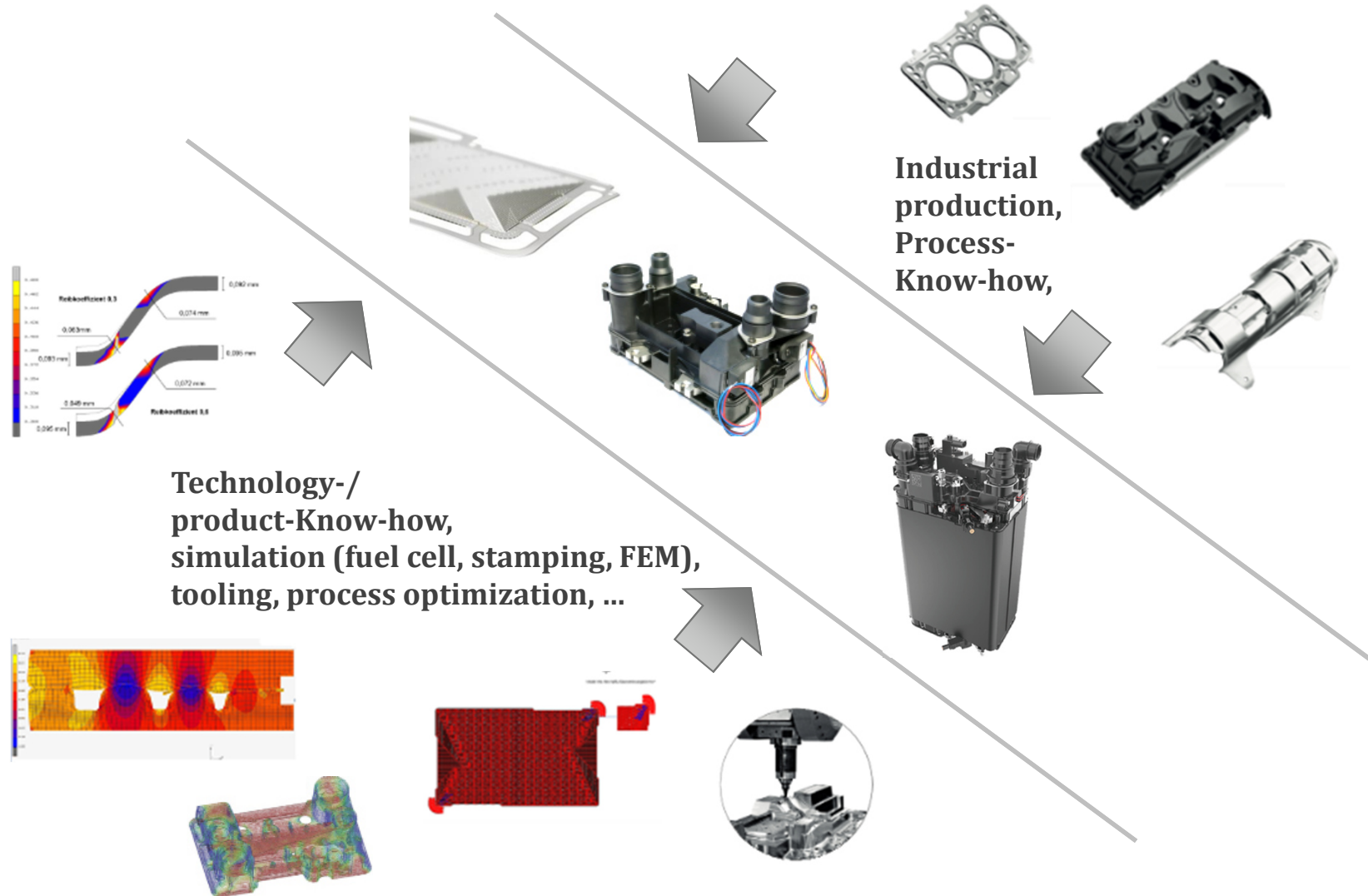


Engine testing services



Tooling technology

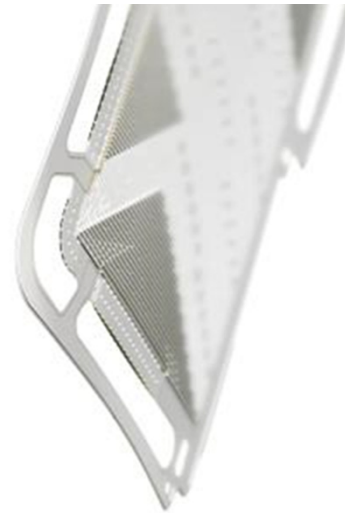
Competences fuel cell components



PEM fuel cell products

Product definition:

- **Sheet metal bipolar plates**
- Elastomer sealings
(optional on bipolar plate assembly)
- **Injection-molded plastic components**
 - End plate
 - Media supply unit
 - System components
- **PEM fuel cell stacks and modules**



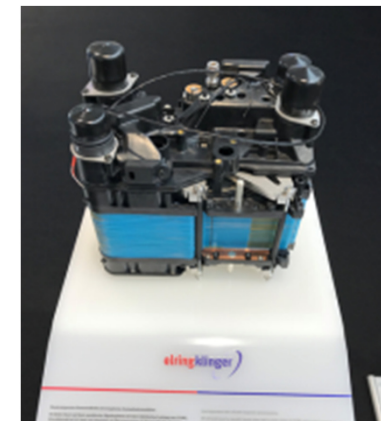
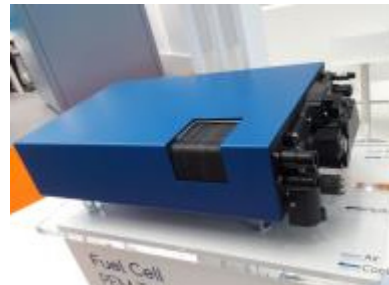
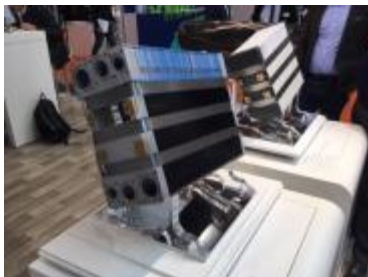
Market situation

Game changer: legislations/requirements for emission control

→ **market pull:** PEMFC Stacks/Systems, mainly cv, truck and bus

Emerging activity in Europe, new suppliers:

Hannover fair 2018: faurecia, plastic omnium,
..., ElringKlinger, Proton Motor, Powercell



New focus: **industrialisation, quality, cost, customer relationship**
background: technology leadership

Challenges

high volume stack production

100.000 FCEV – 100.000 systems – 100.000 stacks

→ 40.000.000 cells

→ ~100.000.000 components/assembly steps

e.g. 10 assembly lines (stack assembly):

2 s per assembly step (sequential processes)

- Very high volumes
- Very high quality requirements, process reliability
 - 400 cell stack, rejected stacks < 1% requires failure rate
 - ~ 1 ppm at single components
- Process stability
 - homogenous, high quality production in three shift operation

Challenges

high volume stack production

100.000 FCEV – 100.000 systems – 100.000 stacks

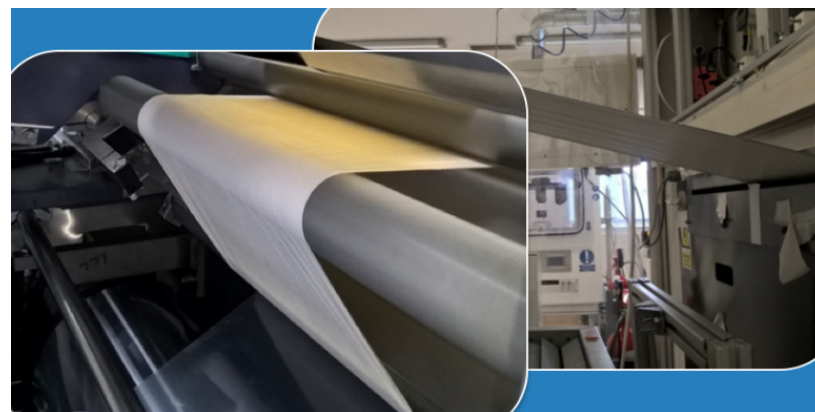
→ 40.000.000 cells

→ ~100.000.000 components/assembly steps

e.g. 10 assembly lines (stack assembly):

2 s per assembly step (sequential processes)

- Product technology (components, stack)
- Manufacturability
- Production processes components and assembly cell/stack
- Processes, quality



→ **Industrialisation**

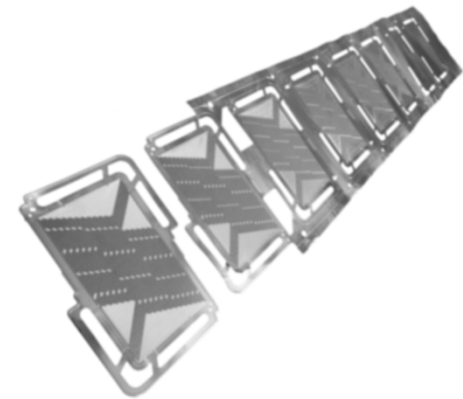
→ **Development product technology – production technology**

Approach

Development of manufacturing technology has to be in line with growing volume

→ **Scalable and modular production concept**

- Parallelisation
- Throughput optimisation
- Continuous processing (e.g. progressive die set)



→ Eliminate/overcome bottleneck processes, e.g.

- end of line test bipolar plate (tightness)
- end of line test stack (incl. break in)

→ Inline control of ctq (critical to quality) and sc features

→ Consistent quality processes, inhouse and along the supply chain,

- traceability
- supply chain management

Production concepts and equipment have to be suitable for the transition to high volume production

Public funded projects - production technology

- [DIGIMAN](#), FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks
- [FIT-4-AMANDA](#), FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks
- [INLINE](#), FCH-01-3-2016: PEMFC system manufacturing technologies and quality assurance
- [INN-BALANCE](#), FCH-01-4-2016: Development of industrialization-ready PEMFC systems and system components
- [MAMA-MEA](#), FCH-02-8-2017: Step-change in manufacturing of Fuel Cell Stack Components
- [VolumetriQ](#), FCH-01.2-2014: VOLUME Manufacturing of PEMFC Stacks for Transportation and In-Line Quality Assurance
- [MontaBS](#), Development of assembly technology and automation concepts for PEMFC stack production
- [Autostack Industrie](#), Development and preparation for mass production of a high performance automotive PEMFC stack

PEMFC stack production

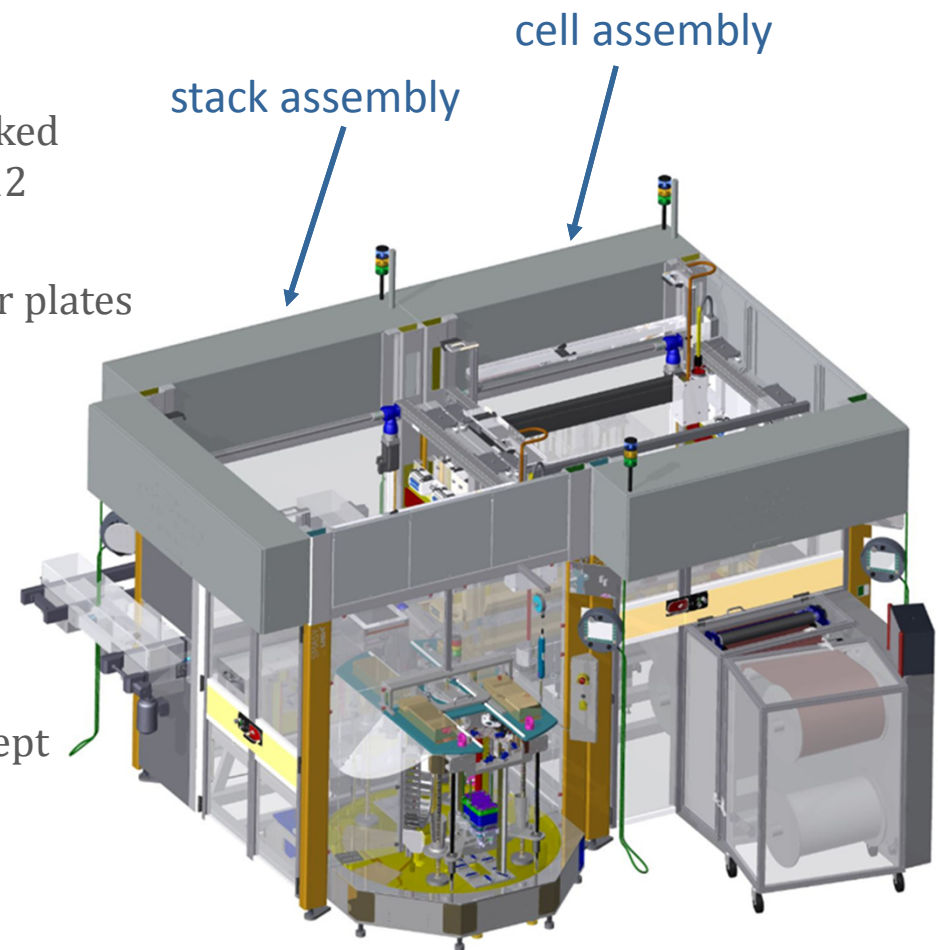
Flexible manufacturing line:

- MEA- and stack assembly cells, directly linked
 - Assembly of stack platforms NM 5, NM 12
- Flexibility in component size and material
 - stacks with metallic and graphitic bipolar plates
 - cell format/size, roll width
- Flexibility in component supply
 - component configurations
 - interfaces for feeding

Targets:

- Development of process/automation concept and plant-/machine technology
- Validation/revision of component design

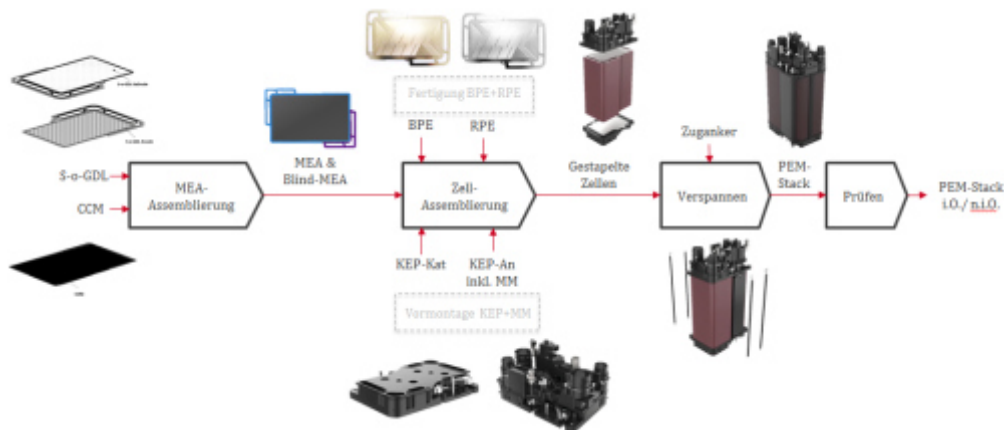
- **high volume production (5000 - 20.000 Stacks p.a.)**



Automatisation cell and stack assembly

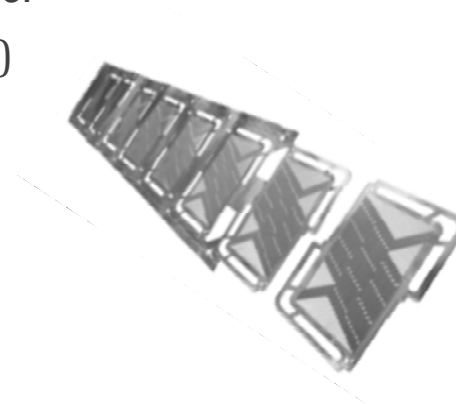
Status

- Commissioning, test operation
- Stack assembly up to 300 cell stack NM 5
- To do:
 - Optimization roll cutting CCM and
 - Stack assembly high cell count



Means for assuring homogenous quality

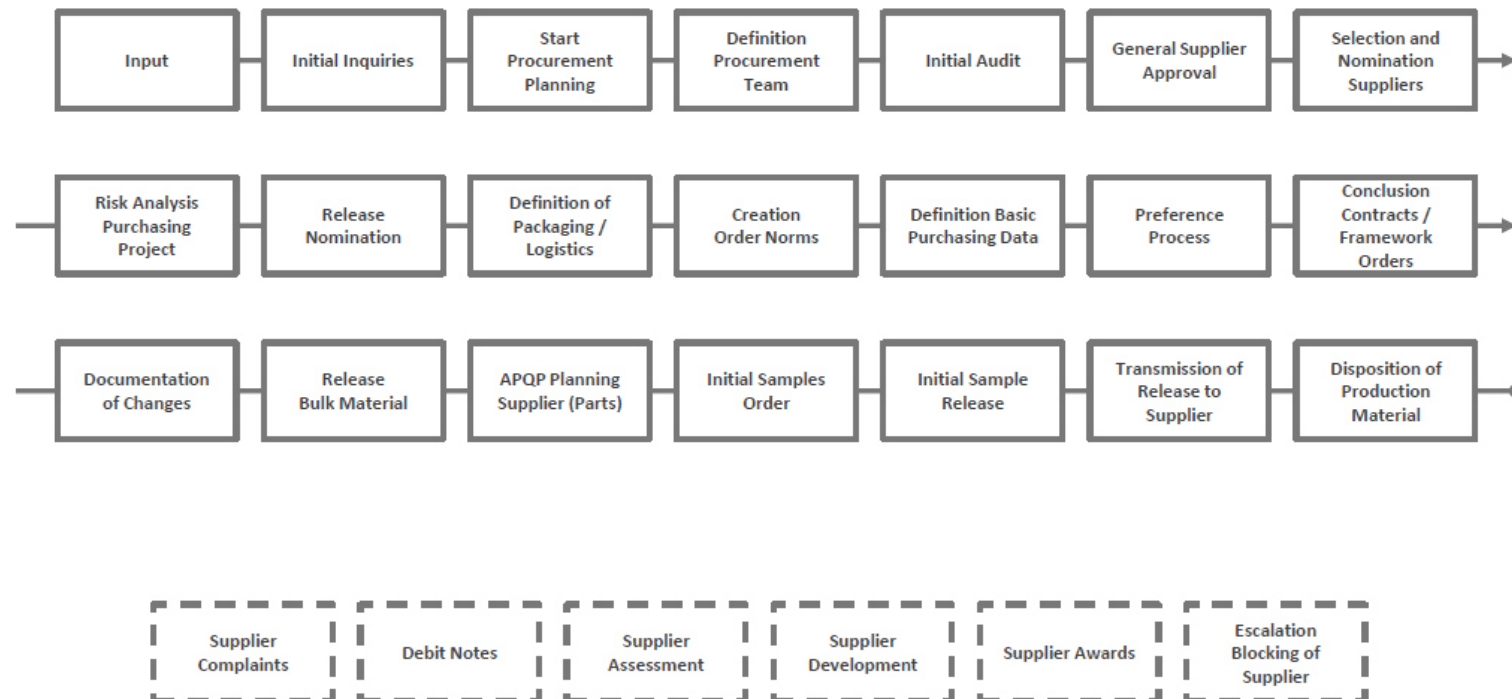
- Process flow according to APQP /PPAP
- Supplier management – Supplier guideline & ordering standards for each material
- Process capability study, measurement capability analysis
- sampling and inspection process, control plan, control drawing, ...
 - e.g. Sample tests (bipolarplate), which may include:
 - Geometrical characterization (non destructive)
 - Pressure drop measurements
 - Tightness test, through-plane and along weld
 - Through-plane resistance measurements
 - Microscopy of cross-cuts (destructive)
 - Cleanliness measurements



Supplier management:

ElringKlinger

Process Flow (Procedure APQP)



Supplier management:

ElringKlinger

Process Flow (Procedure APQP)

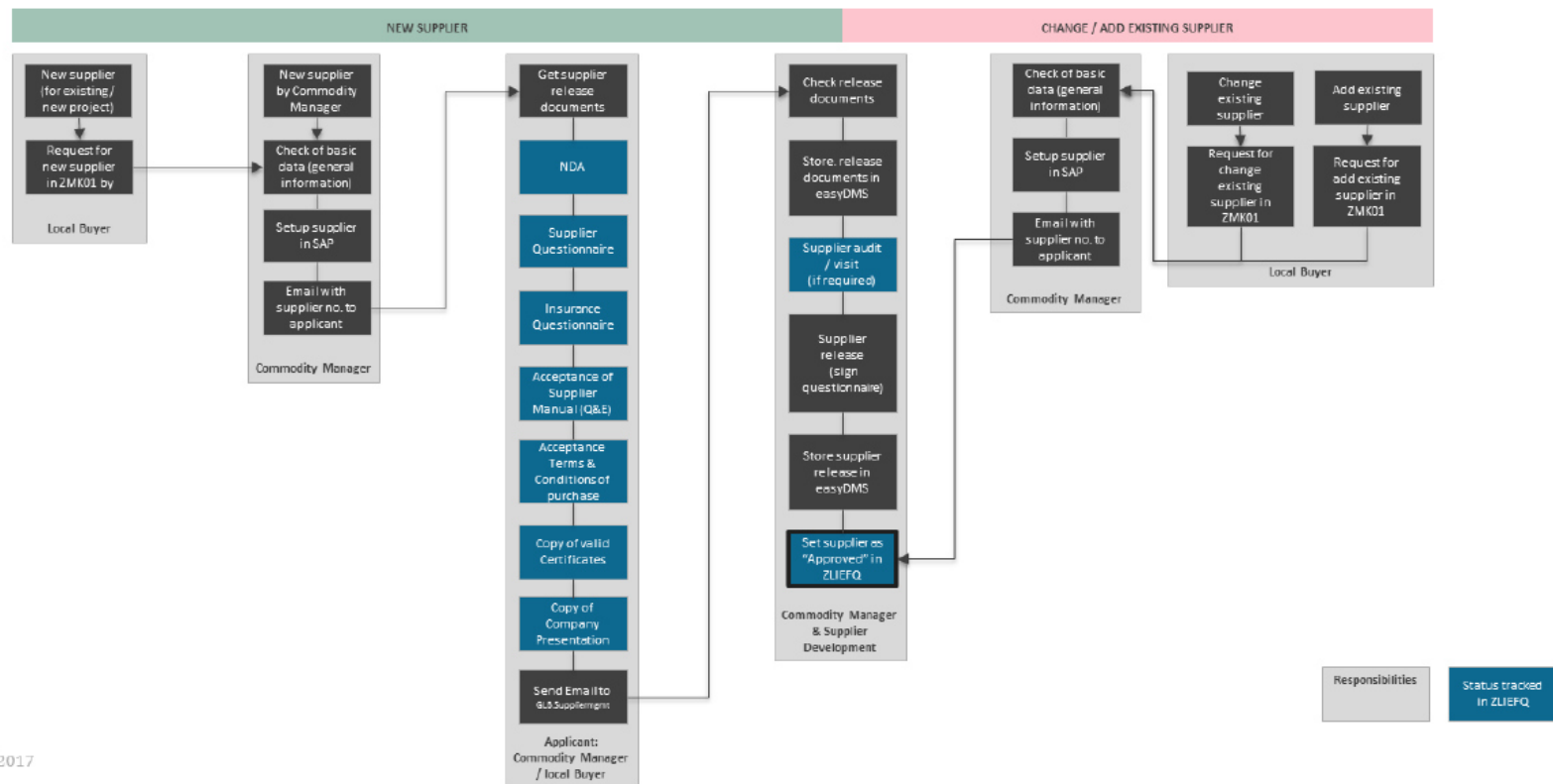
Release of **Bulk Materials**

- | | |
|---|------------------------|
| ▪ Acceptance of order norm from supplier | (Purchase) |
| ▪ Ordering of material samples | (Purchase) |
| ▪ Investigation of material samples | (Development) |
| ▪ Audit / R@R depending on risk
Development) | (Supplier |
| ▪ Release for bulk material | (APQP Team) |
| ▪ can be limited when | |
| ▪ not all tests are done | |
| ▪ documents are missing | |
| ▪ Documentation in Easy DMS and project list SAP ZLIEFP | (Supplier Development) |
| ▪ Send information about approval to the supplier | (Supplier Development) |

Supplier management:

Process Flow (Procedure APQP)

Supplier releasing process



11/6/2017



Internal documentation:

PPAP

Documentation according to VDA or PPAP is standard

PPAP--Dokumente		elringklinger	
Kunde: ***** Customer: *****	PPAP-Level: *****	Datum: ***** Date: *****	
PK-Teil-Nr.: ***** PK-Part-No.: *****	PK-Zeichn.-Nr.: ***** PK-Drawing-No.: *****	Ä-Stand: ***** Customer-Drawing-No.: *****	
Kunden-Teil-Nr.: ***** Customer-Part-No.: *****			
Dokumente	Vorhanden existing	Ablage place for records	Bemerkungen remarks
1. Zeichnung → Design Records	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
2. Änderungsdocuments - Entwicklung → Engineering Change Documents, if any	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
3. Entwicklungstragaba, falls vorhanden → Customer Engineering Approval	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
4. Konstruktions FMEA → Design FMEA	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
5. Prozessablaufplan → Process Flow Diagram	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
6. Prozess FMEA → Process FMEA	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
7. Messergebnisse → Dimensional Results	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
8. Testergebnisse (Material) → Material Performance Test Results	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
9. Vorläufige Prozessfähigkeit → Ppk ≥ 1.67 ± 1.33 - 100% → Initial Process Study	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
10. Prüfmittelprüfung → Measurement System Analysis Studies	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
11. Qualifiziertes Labor (Zertifiziert) → Qualified Laboratory Documentations	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
12. Kontrollplan → Control Plans	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
13. Erstmusterprüfung → Part Submission Warrant (PSW)	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
14. Bericht: Aussehen des Teils → Appearance Approval Report	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
15. Materialanforderungen an Schüttgut → Bulk Material Requirements Checklist	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
16. Musterliste → Sample Products	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
17. Referenzmuster → Master Samples	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
18. Lehren-Prüfmittel usw. → Checking Aids	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
19. Aufzeichnungen der Vorschriften → Kundenspezifischer Anforderungen → Records of Compliance → With Customer-Specific Requirements	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
20. Run et Rate (Ford + GM) → Run et Rate (Ford + GM)	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
21. APQP Summary Sheet	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
22. PPAP von Lieferanten → PPAP from Suppliers	Ja/Yes <input type="checkbox"/> Nein/No <input type="checkbox"/>	*****	*****
Abrechnungstext: 15. Juli 2018 Doc. Code: *****			

Experience mobility – Drive the future.

Thank you.

Dr. Jürgen Kraft
Tel. +49 7123 724 9920
juergen.kraft@elringklinger.com

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by the German Bundestag