THE INFLUENCE OF REGULATIONS ON MATERIAL DEVELOPMENT

8th Triennial International Fire & Cabin Safety Conference

Ralph Buoniconti
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CHEMISTRY THAT MATTERS™

CONTENT

SABIC BY THE NUMBERS

1976, our beginning
40 years of growth

3rd largest global diversified chemical company*
116th largest public company in the world*

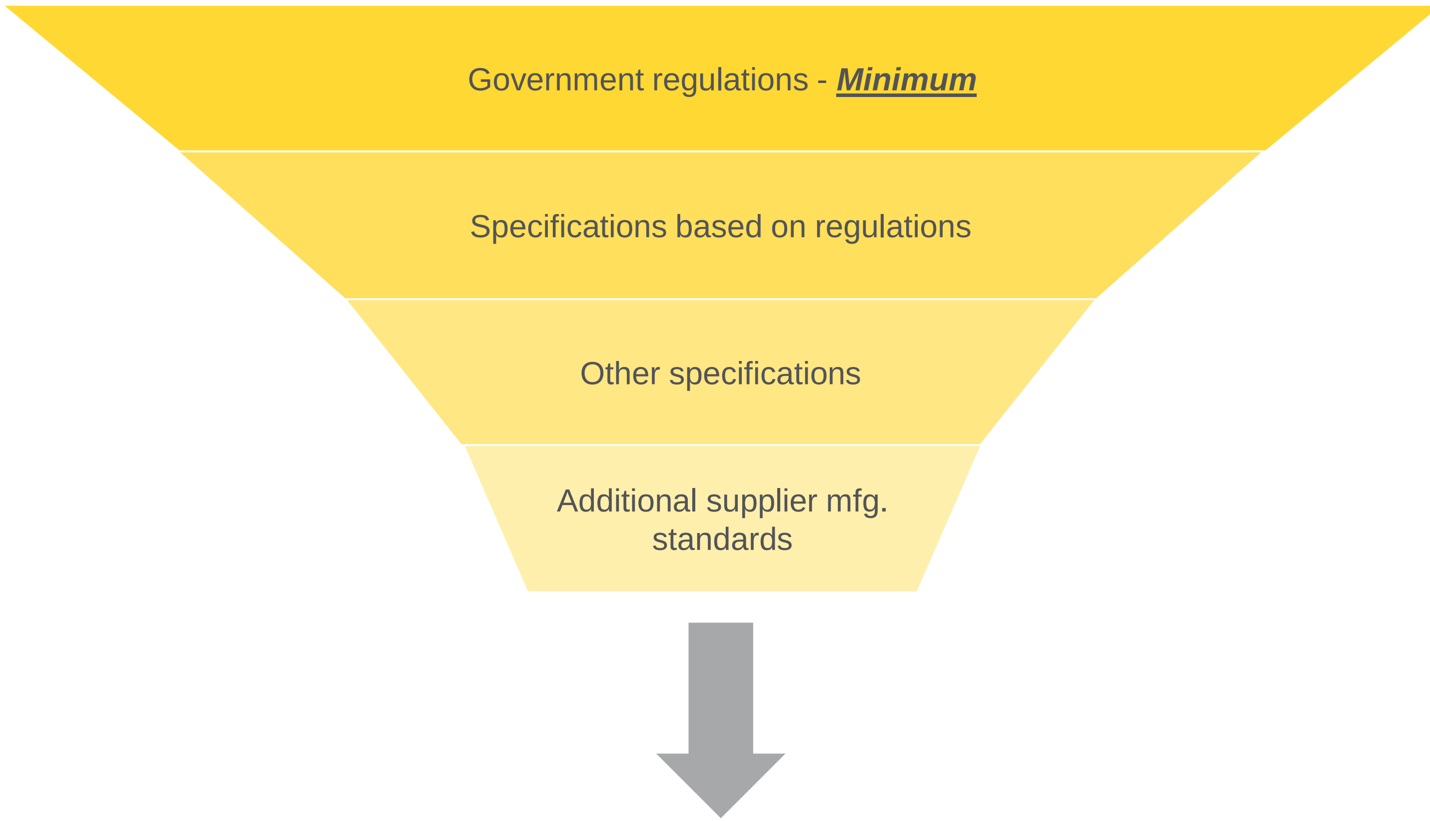
87.53 B$ total assets
39.49 B$ annual revenue
5 B$ net income

40,000 employees
50 countries
5 Strategic Business Units

64 world-class plants worldwide
5 key geographies with innovation hubs
150 new products each year
10,960 global patent filings

* Forbes 2015

REGULATIONS ARE JUST A BEGINNING

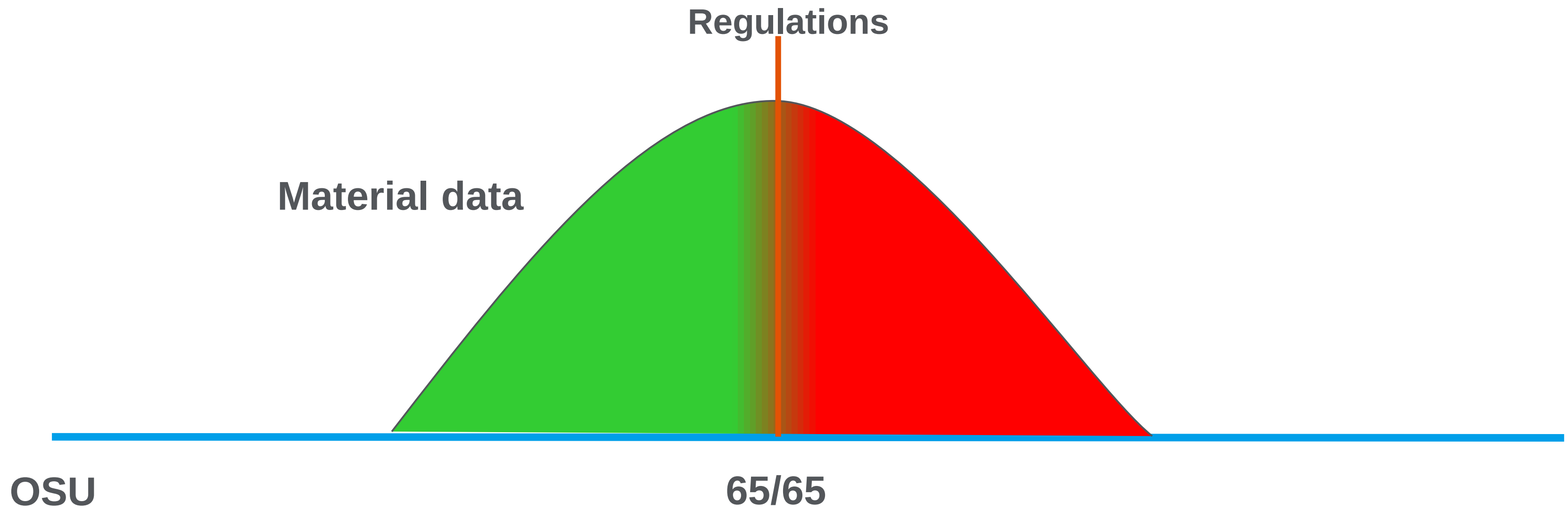


Regulatory requirements, by their nature, tend to be a starting point in material development. Other requirements tend to narrow options further.

REGULATIONS AND MATERIAL DEVELOPMENT

FROM REGULATIONS TO SPECIFICATIONS

REGULATIONS ARE JUST A BEGINNING

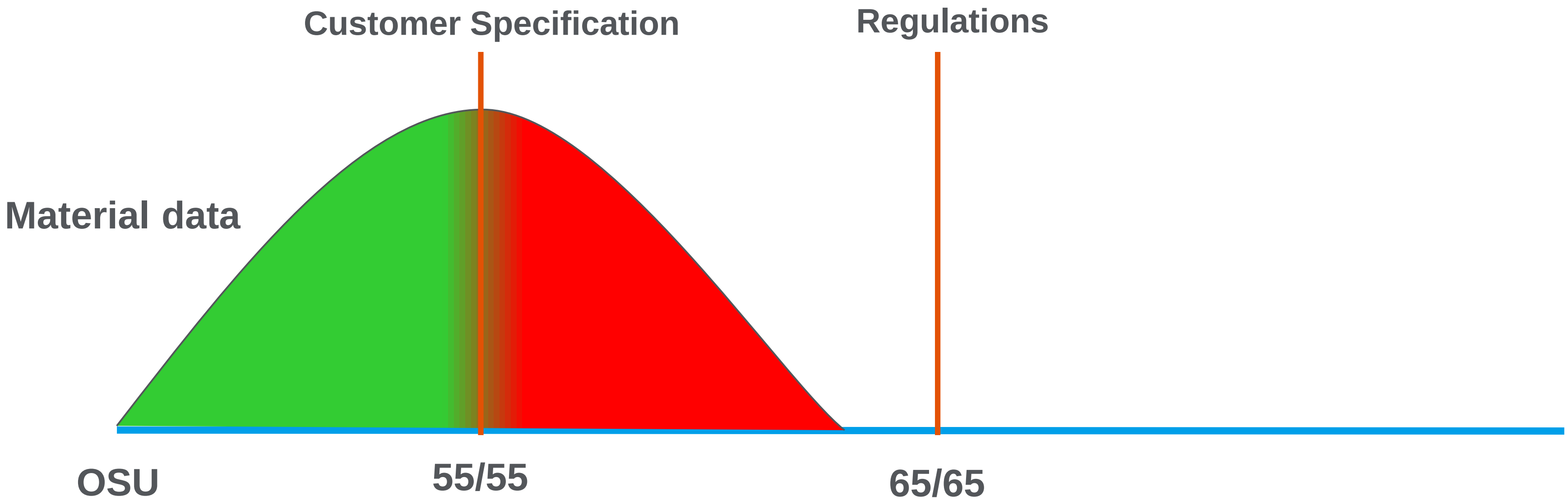


Since failing lots are unusable:

- Lot-to-lot testing eliminates half of the material?
- What to do about the “blurry” middle (ex: 1 outlier pushes average into either passing or failing)
- What if intra-lot variability plus the testing variability causes this testing distribution ***within*** a lot?

Not an ideal situation.

SPECIFICATIONS – THE “HIDDEN” REGULATIONS



Failing a specification is not necessarily as consequential as failing the regulation, but:

- Failing lot could be rejected
- There is still the “blurry” middle
- If material is part of a composite in end-use, a “small” specification failure could result in a composite regulatory failure

Even with added the safety, designing *to* a customer specification has risks

SUPPLIERS CAN ADD ADDITIONAL SAFETY FACTOR

Now:

- A material that fails an internal supplier specification still could meet customer specifications
- Chances of a material failing the regulations become very remote
- There really is no “blurry” middle

One of the best situations when meeting/exceeding regulations is ultimate goal

REGULATIONS AND MATERIAL DEVELOPMENT

WHEN REGULATIONS ARE CHANGING

WHEN REGULATIONS CHANGE

Nature of change is critical:

Case 1: Decrease variability within an existing test… including lab-to-lab variability
- Will an accredited lab become more severe as a result?
- Was a material depending on such a lab for data?

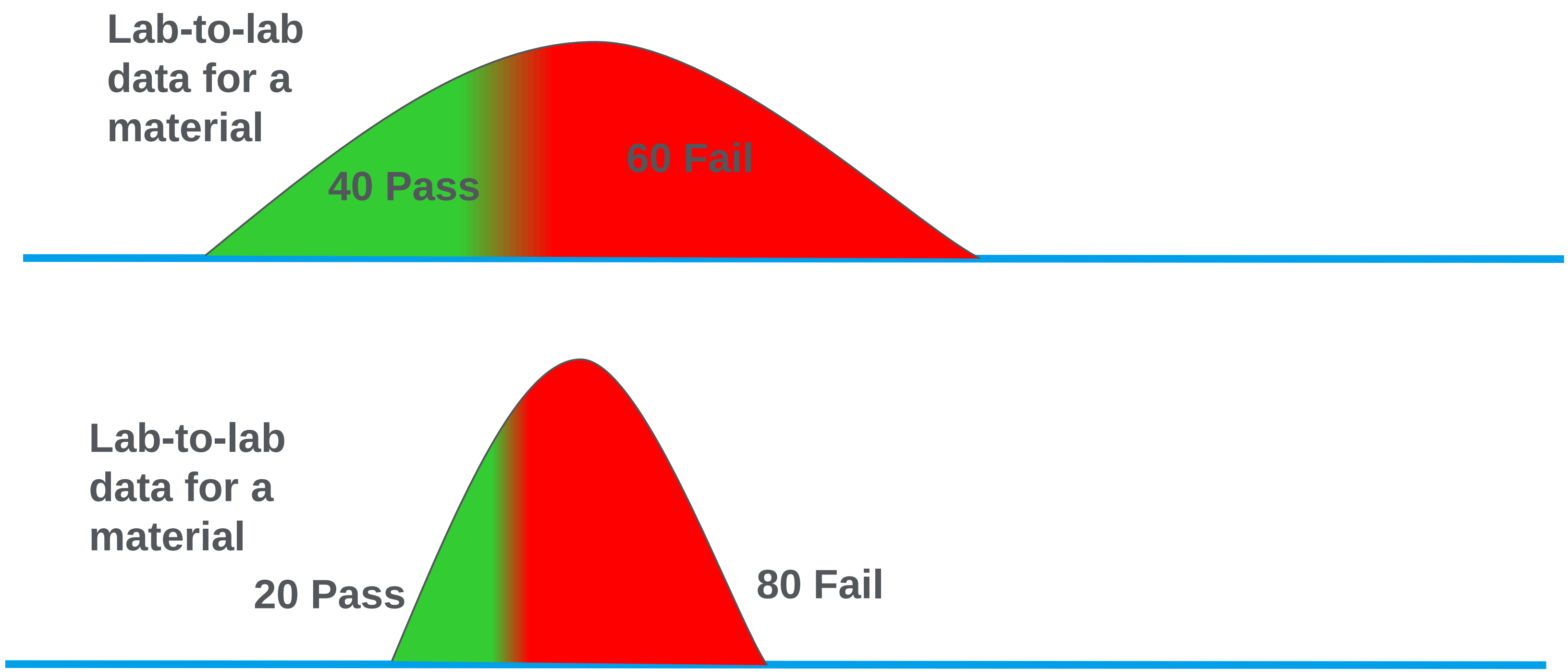
Case 2: Increase requirements of existing test, or add an existing (known) test
- Will current product meet the increase/added test?
- Can current product be “changed” to meet the increase/added test?
- Will a new product be needed?

Case 3: New test is being developed and added to the regulations.
- Where and when to focus?

Case 4: Decreasing requirements of existing tests
- Being discussed as potentially part of new rule (vertical burn tests & smoke)
- Existing applications may see a decline in small scale fire performance

Be aware of underestimating the impact of a change

CASE 1: DECREASING LAB-TO-LAB VARIABILITY

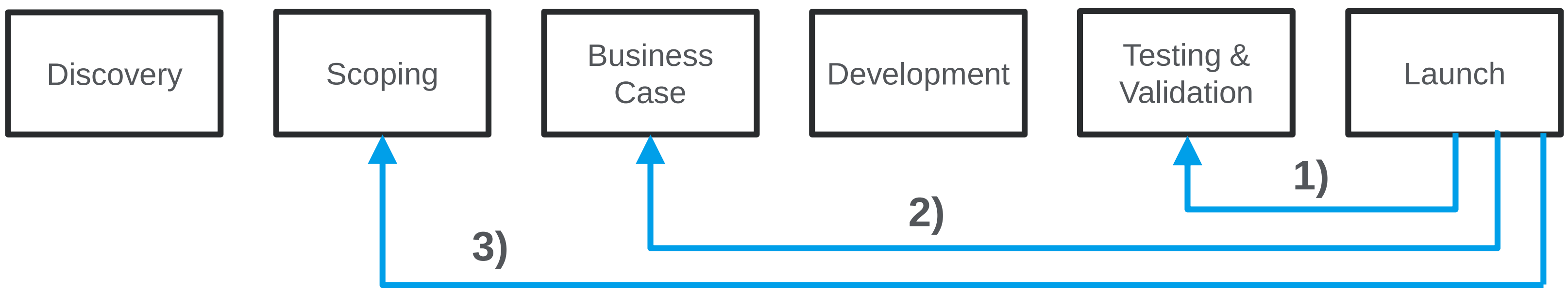


Unintended consequences, which may have no “solution,” except product development

CASE 2: INCREASE REQUIREMENTS / ADD AN EXISTING TEST

1) Will current product meet the increase / added test?
2) Can current product be modified to meet the increase/added test?
3) Will a new product be needed?

Product development in a Phase-gate Process**



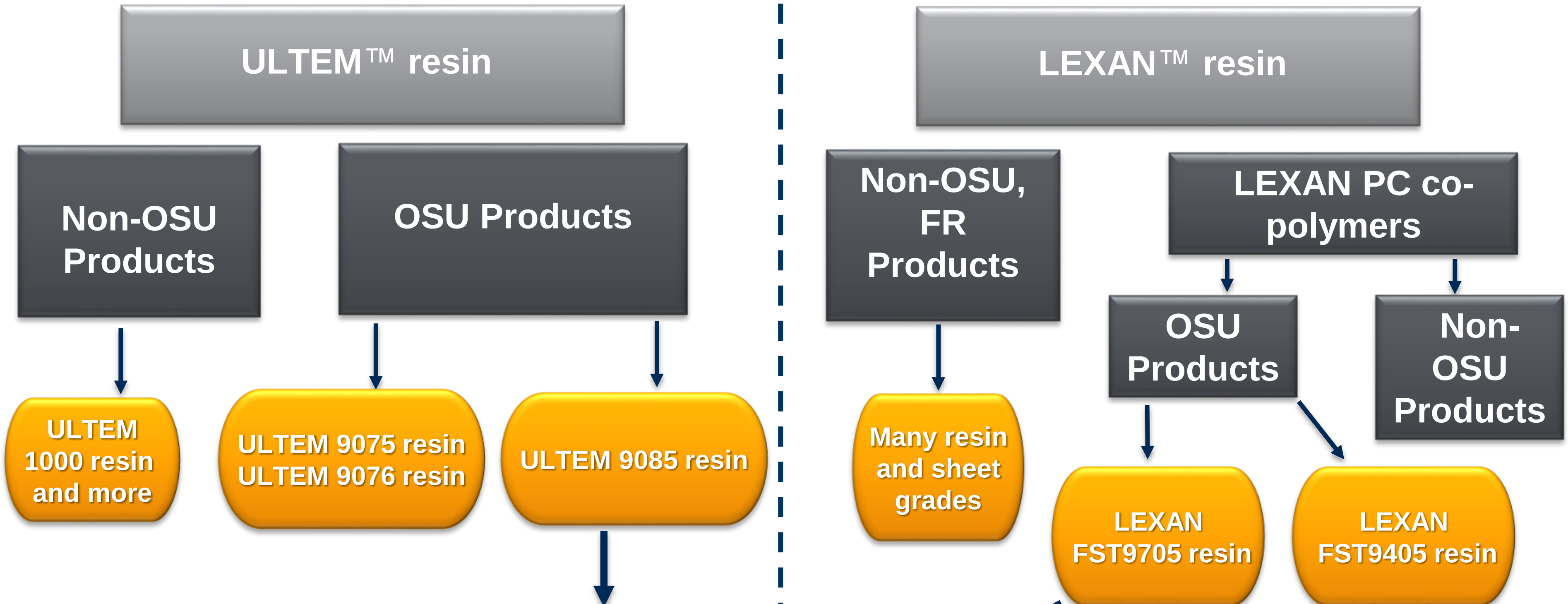
Even for simplest route:

- How many lots need to be tested?
- Is underlying distribution acceptable for internal specifications, customer specifications, and ultimately regulations?
- Will specifications need to be changed?

Product changes bring much more uncertainty, time, and development costs

** Model Phase-gate stages from Wikipedia

AIRCRAFT PRODUCTS IN LARGER PORTFOLIOS



ULTEM 9085 resin:

- Better flow, impact, processing
- App. 3 years, ***after*** new resin development
- Cost: in the millions of dollars, ***after*** new resin development

LEXAN FST9705 resin:

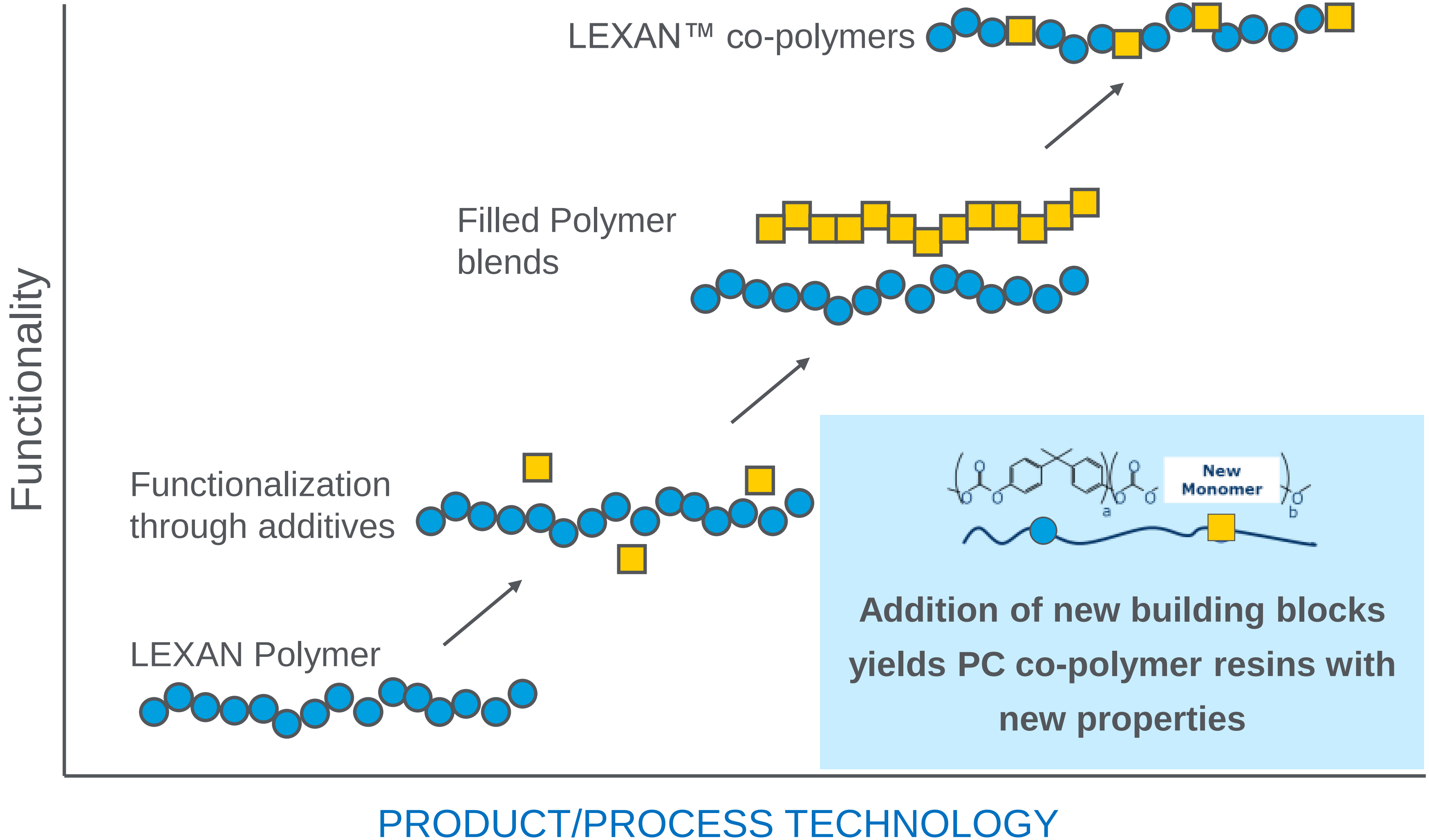
- ***New*** resin platform
- App. 5 years in development
- Cost: Several $MM

LEXAN FST9405 resin:

- Higher flow
- 5 years in development
- Cost: $MMs

“Similar” products in a portfolio can vary widely in developmental complexity & cost

NEW TECHNOLOGIES



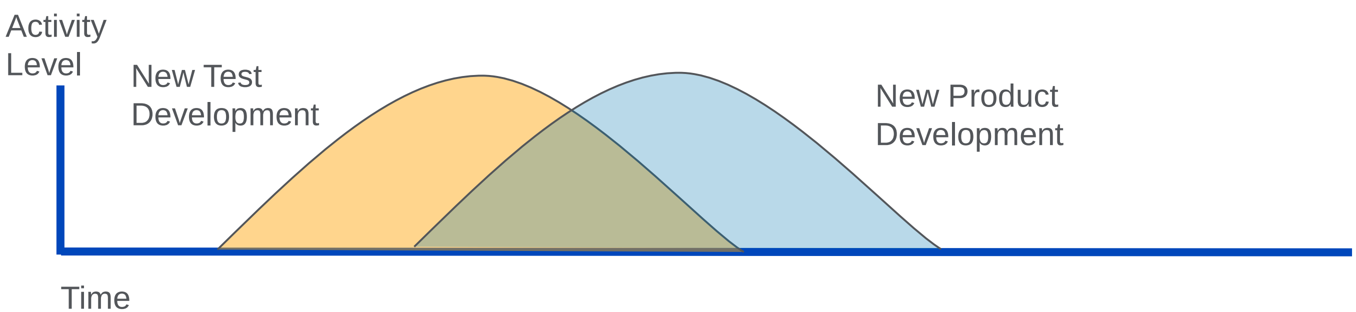
CASE 3: DEVELOPMENT OF NEW REGULATORY TEST

Material developers using a Phase-gate** process:

Discovery → Scoping → Business Case → Development → Testing & Validation → Launch

- May spend a lot of time in these gates
- Large scale concerns and tests become intermediate tests
- Intermediate tests become lab-scale

- Test of existing materials?
- Product development necessary?
- Invention needed?
- Timing of regulations



In this case, product development generally lags new test development

** Model phase-gate stages from Wikipedia

CASE 4: DECREASING REQUIREMENTS OF EXISTING TESTS

Example: Two currently commercialized aircraft grade SABIC materials

	12 second vertical BB			60 second vertical BB		
Product (both 0.080")	Avg. burn length (in.)	Avg. burn time (sec.)	Longest burning particle (sec)	Avg. burn length (in.)	Avg. burn time (sec.)	Longest burning particle (sec)
1	0.7	5.1	N/A	4.6	55.2	10.0
2	0.8	0.3	N/A	3.4	3.3	2.5
1	0.7	5.1	N/A	4.6	55.2	10.0
2	0.8	0.3	N/A	3.4	3.3	2.5

Current criteria:
1 = 12 sec. VBB
2 = 60 sec. VBB

Potential criteria**:
1 & 2 = 60 sec. VBB

** Discussed as potentially part of the new rule.

Under the potential criteria, as customers purchase a different product mix, aircraft components could see a reduction in small-scale fire performance

** Model phase-gate stages from Wikipedia

REGULATIONS AND MATERIAL DEVELOPMENT

EXAMPLE:
VERTICAL FLAME PROPAGATION (VFP) TEST

VFP – BRIEF HISTORY OF A NEW, PROPOSED TEST

Development

- Initial intended use: composites (skins, structural elements) in hidden spaces
- Meant to be more severe than current 12 second vertical burn test
- Large scale data, reduced to intermediate test, reduced to lab-scale test
- Lab scale test and metrics designed around composite reaction-to-fire

Problem

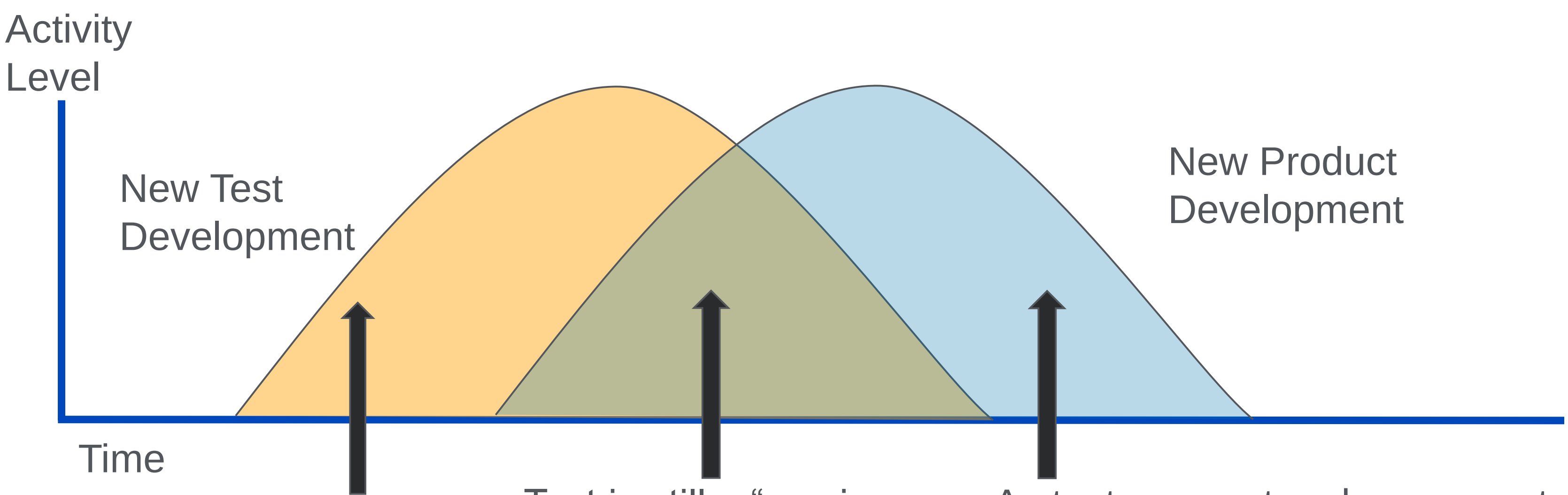
- Scope changed to potentially include any “large” material in hidden spaces
- With first thermoplastic tested, a problem was discovered… invalid results

Problem resolution

- More product testing – find extent of problem
- Various proposed “fixes”
- Settled on changes to the equipment, which leads to more tests.

A change in scope could change stakeholders, products covered, and test fundamentals

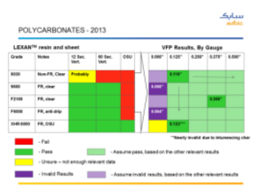
VFP CYCLE FROM PRODUCT DEVELOPMENT VIEWPOINT

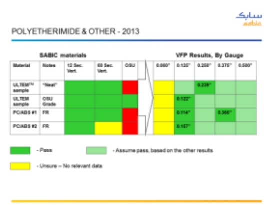


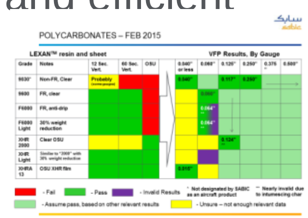
Data generated here probably not translatable to final test

Test is still a "moving target", data may not be translatable to final test.

As test parameters become set and data becomes better understood, relevant data becomes more clear. Product development becomes more focused and efficient







For thermoplastics, hidden assumptions in fire tests are critical to uncover

REGULATIONS AND MATERIAL DEVELOPMENT

REACTION-TO-FIRE PROPERTIES AND FIRE TEST METRICS

MATERIAL REGULATORY REQUIREMENTS = FAA FIRE TESTS

Thermoplastics

- By definition: shaped by heat. Can “melt”, soften, flow. All could be reaction-to-fire behaviors under direct flame and/or radiant heat.
- Some will not “puddle” in fire tests, but may drip small or large pieces.
- Some will not drip at all in the FAA’s OSU, vertical burn, or smoke tests.
- In general, higher heat, better “FR” materials, will soften and drip much sooner than they will burn. Will vary depending upon fire conditions and material.

Good or bad reaction-to-fire behavior?

- Fire risk scenarios dictate which behaviors are desirable or not.

Specific materials may have a “surprise”, but known reactions-to-fire should not

- Aircraft interiors have used plastics for several decades.
- High intumescing materials are not new & are used in many industries, including aircraft.
- High end composites, with “popping” and “spalling”, are also known

FAA tests need to account for foreseeable reaction-to-fire properties in any new or modified test meant for multiple materials

NEW TECHNOLOGIES & INTUMESCING FIRE PERFORMANCE

STD. FR POLYCARBONATE OR FR PC/ABS:

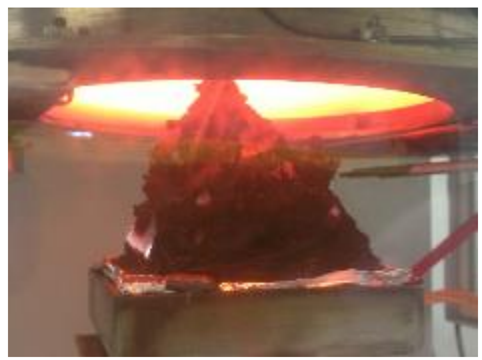
- Loose & unstable char,
- Fails OSU & Smoke Density (PC/ABS)

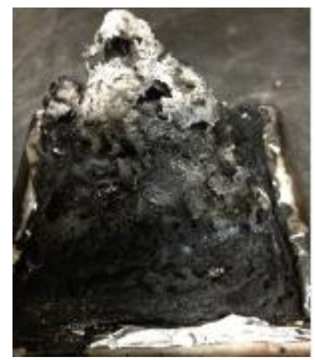
MINERAL FILLED FR PC/ABS:

- More stable char formation,
- Improved HRR & Smoke density
- OSU is still difficult to pass

LEXAN™ CO-POLYMERS :

- Stable and compact char formation
- Specific grades have low OSU and smoke numbers (comfortably passing FAA requirements)





SUMMARY – PRODUCT DEVELOPMENT AND REGULATIONS

- Regulations are a “beginning” for safety
- Customer specifications can be just as important for product development
- No change in fire-test regulations should be seen as minor, without thorough investigation
- Where possible, material suppliers need to be involved in fire test development
- Unless a test is specific to a material (e.g., magnesium alloys), a fire test needs to account for all foreseeable reaction-to-fire behaviors

Thank you for attending.

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