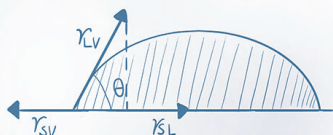
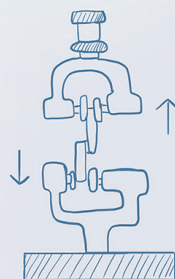
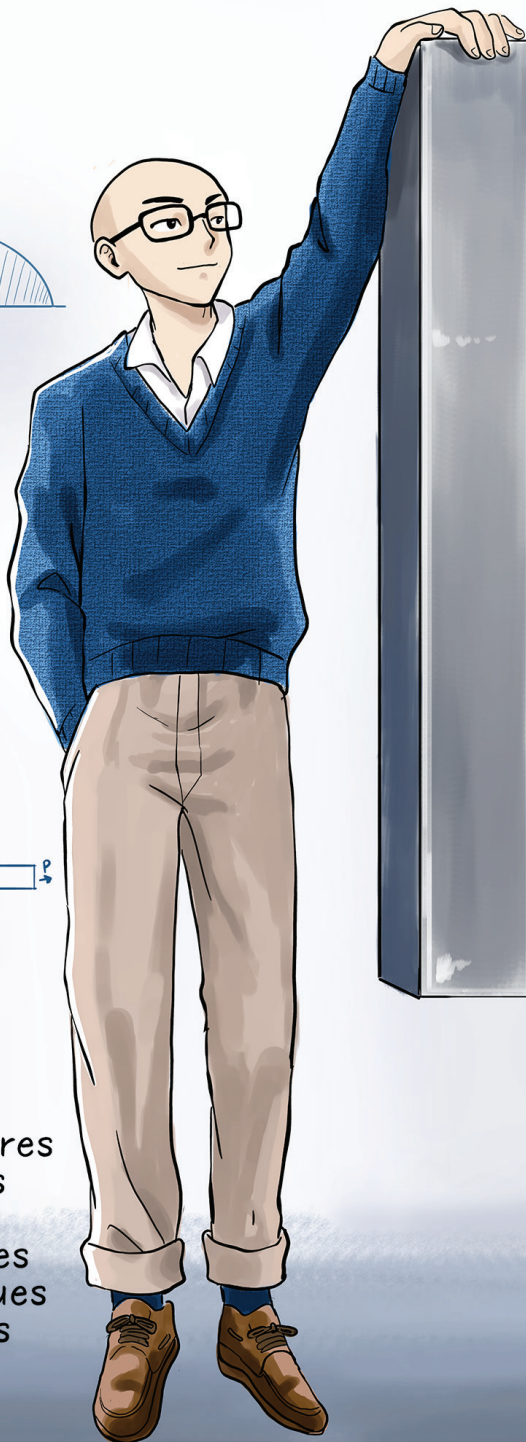


THE UNBREAKABLES



STORY BY:
Margarida Soares
Beatriz Simões
Maria Ferreira
Vasco Rodrigues
Eduardo Marques
Ricardo Carbas
Lucas Silva



THE MANGA
WAY TO
LEARN
ADHESIVE
BONDING

ART BY:
Filipe Rolo

STORY BY

Margarida da Costa Belo Vinhas Soares
Beatriz Duarte Simões
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Filipe Manuel Raimundo Grácio Rolo

TITLE

The Unbreakables - The Manga Way to Learn Adhesive Bonding

PUBLISHER

Quântica Editora – Conteúdos Especializados, Lda.
Tel. 220 939 053 . E-mail: geral@quanticaeditora.pt . www.quanticaeditora.pt
Praça da Corujeira n.o 38 . 4300-144 PORTO

IMPRINT

Engebook – Conteúdos de Engenharia

DISTRIBUTION

Booki – Livraria Técnica
Tel. 220 104 872 . E-mail: info@booki.pt . www.booki.pt

PRINTING

September, 2026

LEGAL DEPOSIT

570016/26



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UDC

621.7 Mechanical Engineering Technology in General. Processes. Tools. Machines. Equipment
621.79 Welding, Adhesive Bonding, Surface Treatment and Finishing

ISBN

Print Edition: 9789899305489

E-book Edition: 9789899305496

Cataloguing Information

Subject Area: Mechanical Engineering

Subfield: Technology / Manufacturing

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THE UNBREAKABLES' TEAM



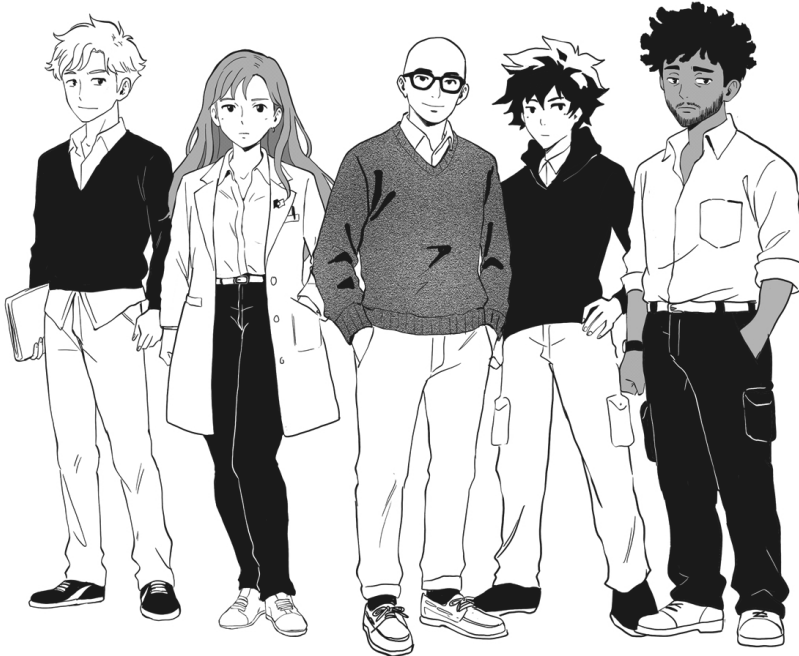
ANGELA

ALLERGIC TO SHORTCUTS AND NONSENSE. THE ONE GUIDING JOVI THROUGHOUT THE EXPERIMENTS AND MAKING SURE LEON'S JOKES ARE UNDERSTOOD.
FUN FACT: ONLY TRUSTS AN ADHESIVE AFTER TESTING IT MULTIPLE TIMES. SAME APPLIES TO PEOPLE.



JOVI

THE STUDENT. NEW TO THE FIELD, QUICK TO ASK THE QUESTIONS EVERYONE ELSE STOPPED ASKING YEARS AGO. TAKES THINGS A LITTLE TOO LITERALLY SOMETIMES.
FUN FACT: STILL HASN'T FINISHED READING THE BOOK.



FELIX

DATA-ORIENTED, CALM AND PATIENT. LOGS EVERYTHING, CROSS-REFERENCES STRESS CONCENTRATIONS AND SPEAKS FLUENT CAD. DOESN'T MIND TAKING THE TIME TO EXPLAIN TO JOVI.
FUN FACT: HE HAS A FAVORITE POINT ON THE STRESS-STRAIN CURVE. IT'S THE YIELD POINT. HE FINDS FRACTURE "TOO DRAMATIC".



LEON

THE PROFESSOR. BELIEVES NEVER DO TOMORROW WHAT YOU CAN DO TODAY. DELIVERS DEVASTATING SENTENCES WITH A COMPLETELY STRAIGHT FACE.
FUN FACT: HE IS ALWAYS RIGHT.



OLIVER

DRY, DEADPAN AND OCCASIONALLY INTIMIDATING IN A WAY THAT'S SOMEHOW REASSURING. HAS AN EVIL GRIN RESERVED SPECIFICALLY FOR TERRIFYING JOVI.
FUN FACT: IF THERE'S NO MACHINE FOR THE JOB OR IT'S TOO EXPENSIVE, HE HAS PROBABLY ALREADY BUILT ONE.

DORA



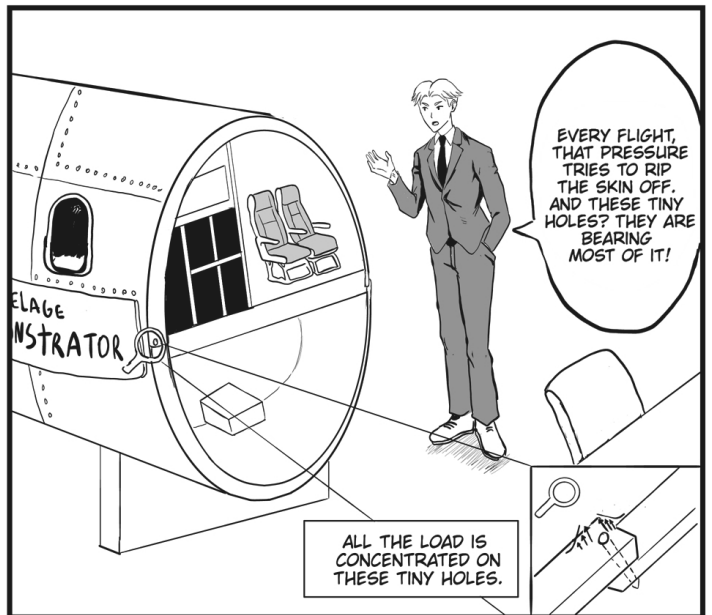
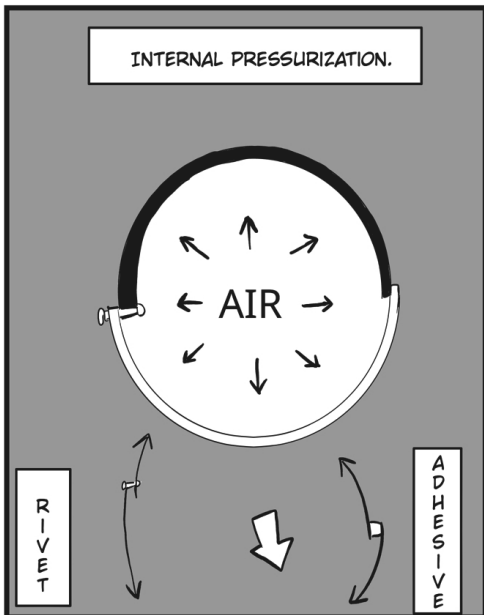
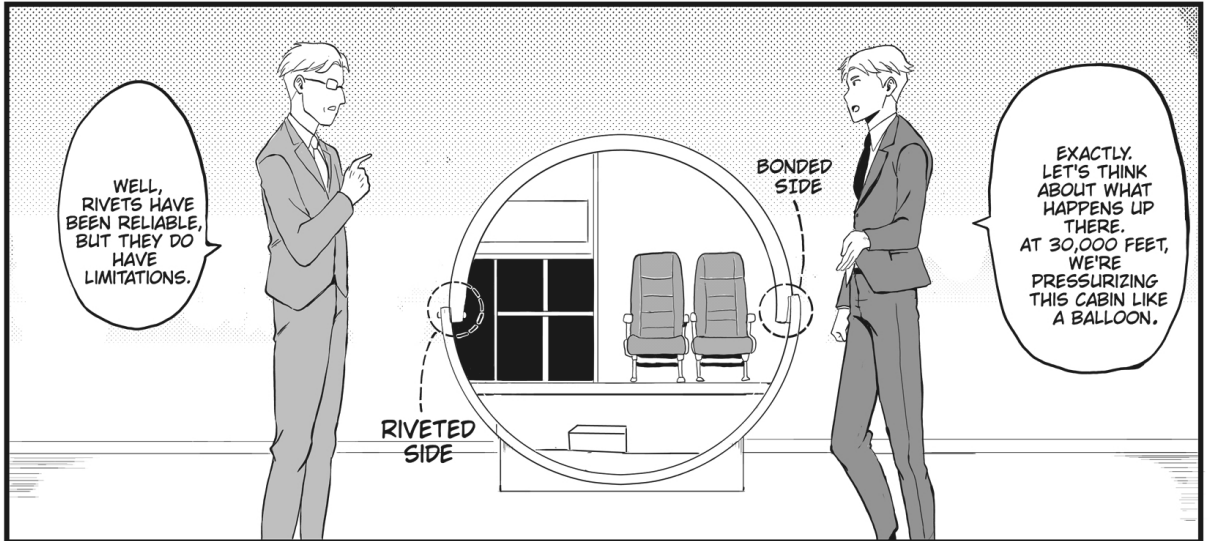
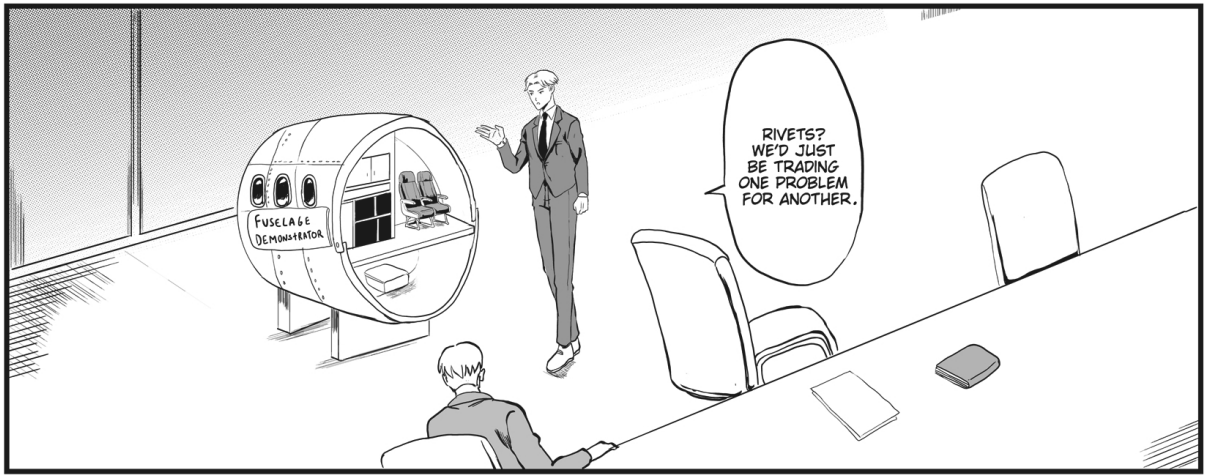
AMGO'S COMPANY

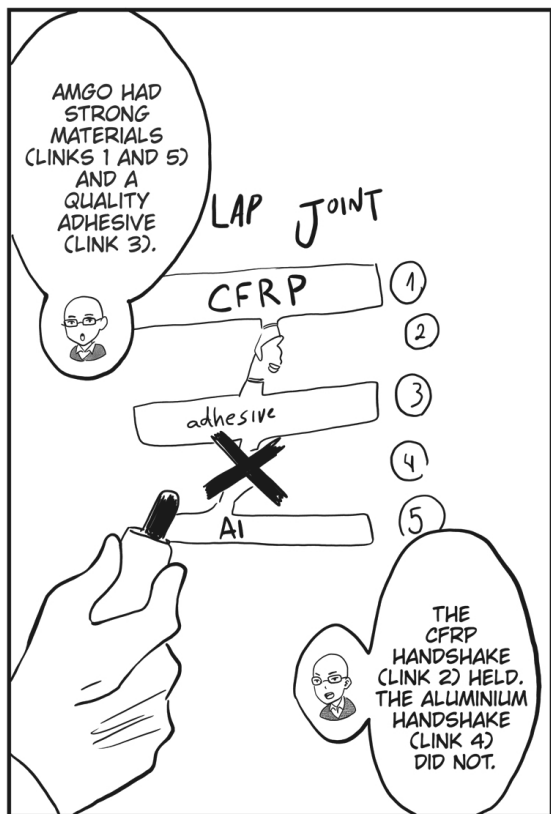
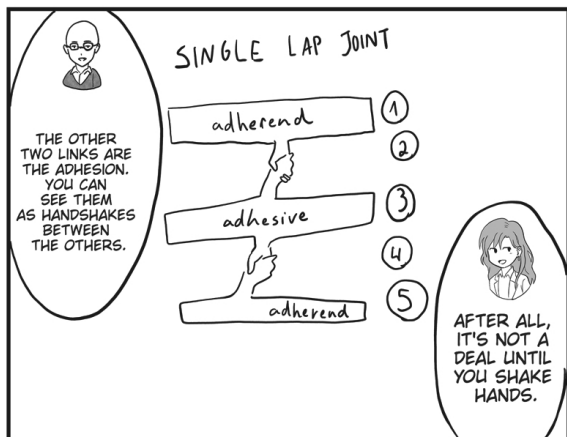
AMGO'S REPRESENTATIVE, CAUGHT BETWEEN THE BOARD'S DEADLINE AND AN ENGINEERING PROBLEM THAT DOESN'T CARE ABOUT DEADLINES.
FUN FACT: HAS LEARNED TO SAY "WE CANNOT SHARE IT" IN AT LEAST FOUR DIFFERENT TONES OF VOICE.

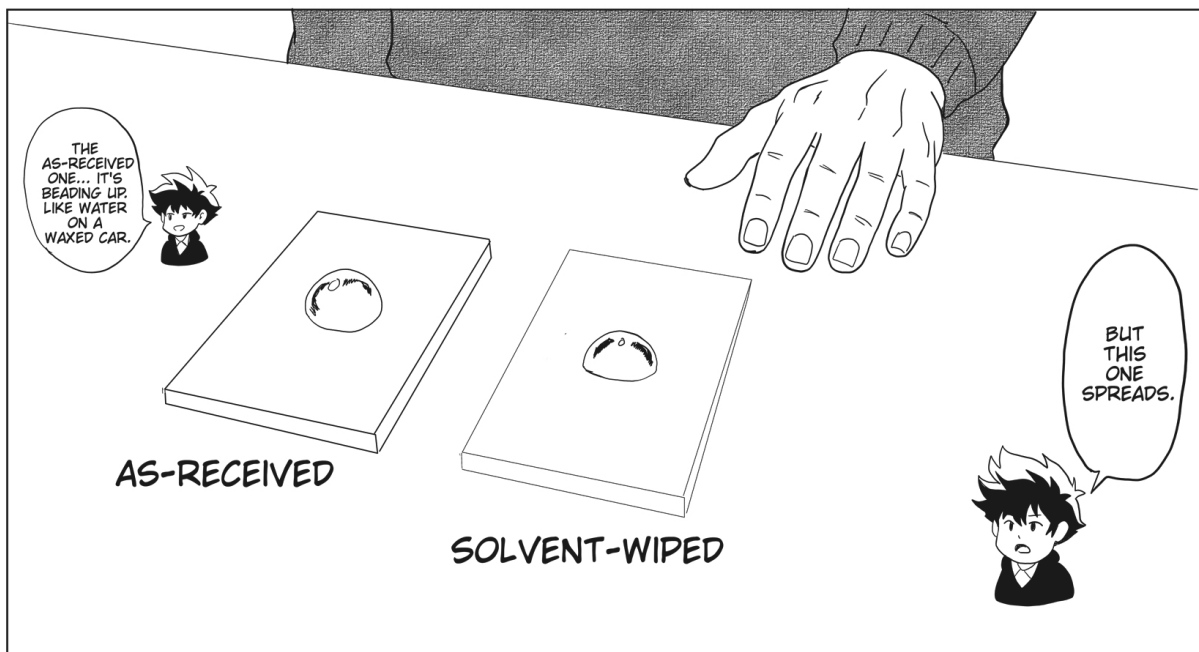
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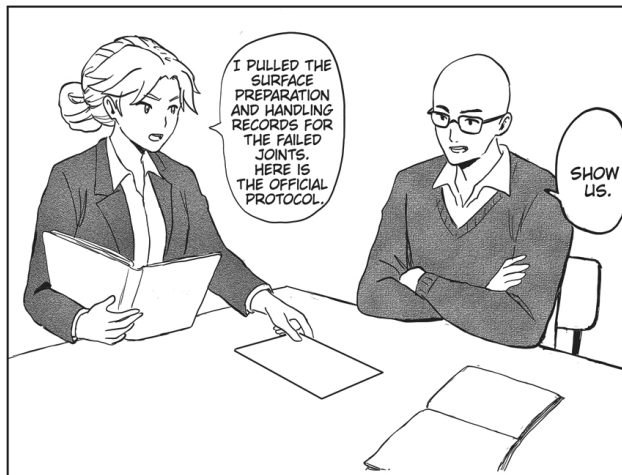
THE BOND THAT BROKE









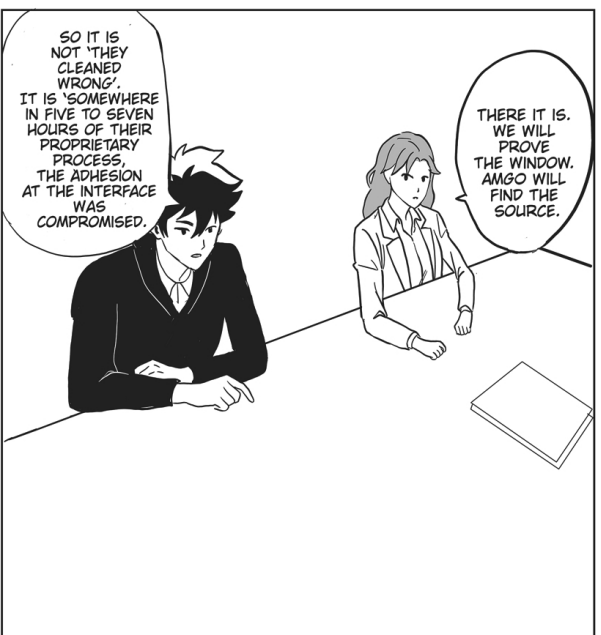
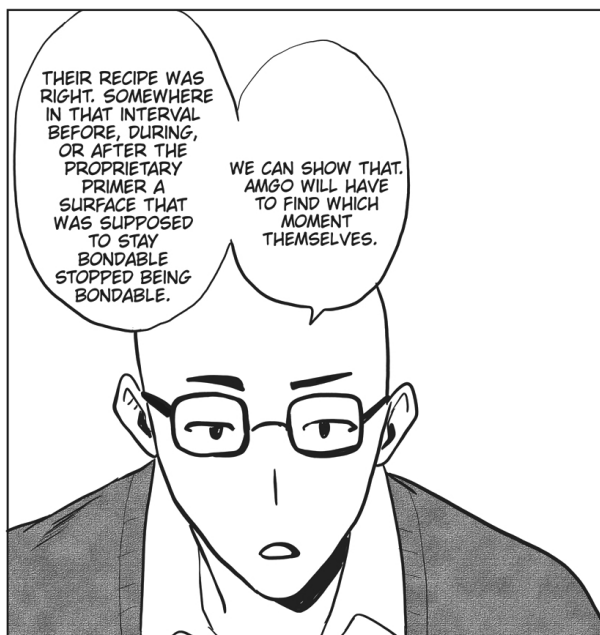


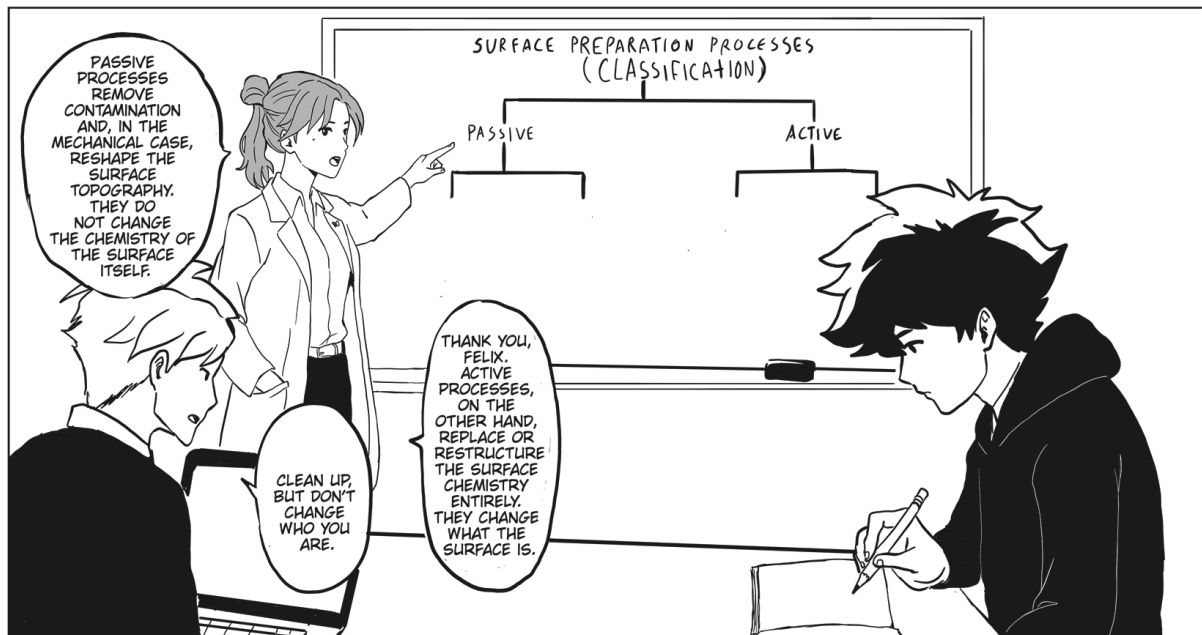
AMGO MANUFACTURING PROCESS SHEET

Step 1: Degrease aluminium surface — solvent wipe, two-pass.	✓
Step 2: Mechanical abrasion.	✓
Step 3: Anodise (PAA).	✓
Step 4: Apply Proprietary Primer AMGO PROCESS A12 [chemistry CONFIDENTIAL]. Cure window per Process A12.	✓
Step 5: Apply structural adhesive.	✓

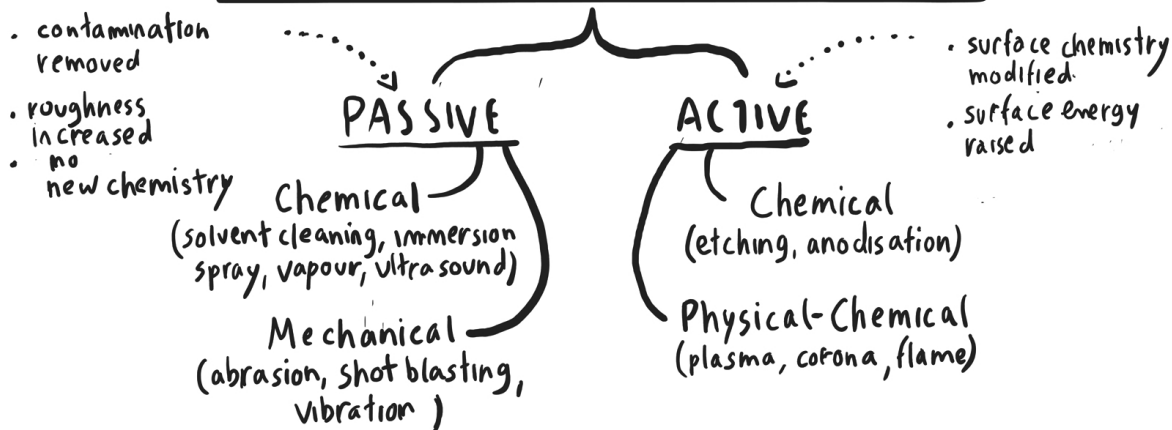
Handling log:

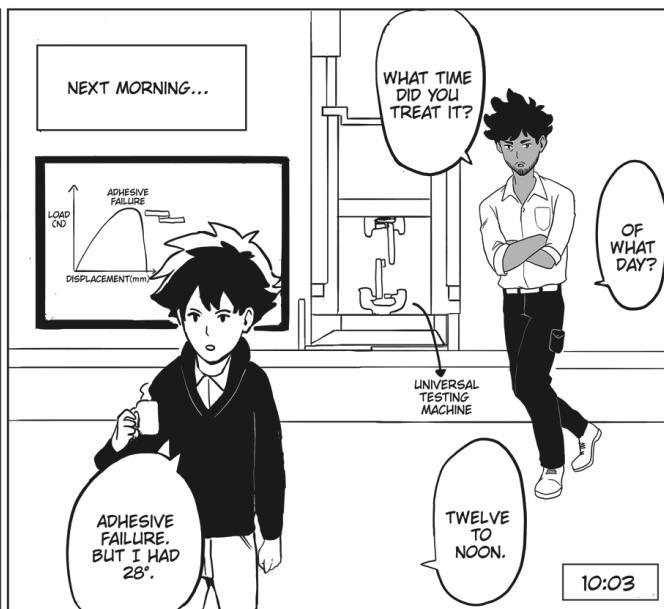
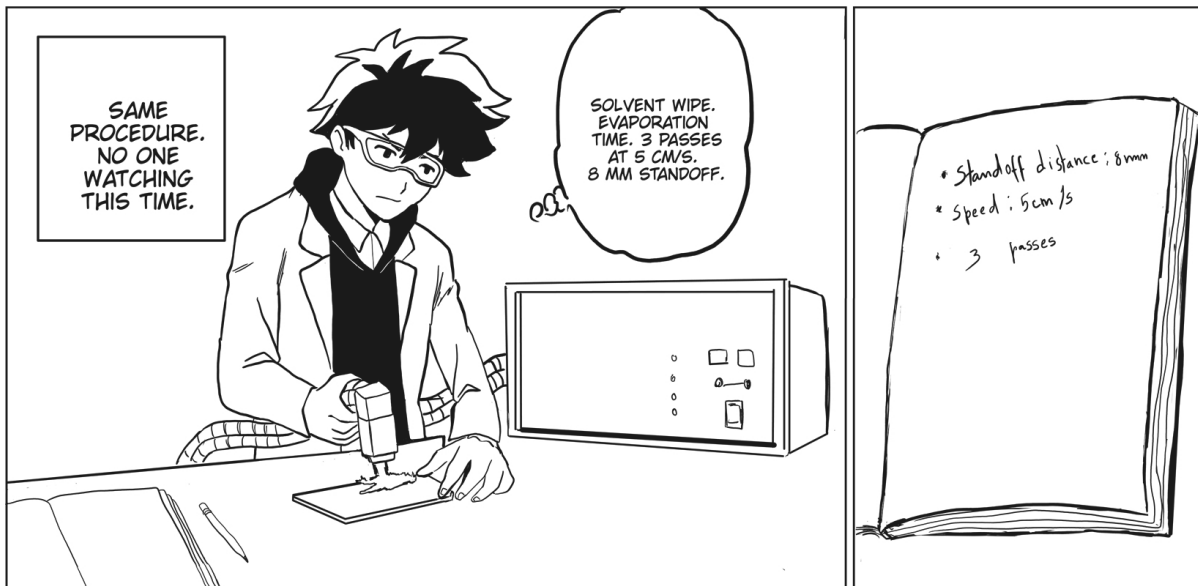
- . Part on production line throughout.
- . Total elapsed time between primer application and adhesive: 5–7 hours (Process A12 cure + Step 5 staging).





Surface Treatment Classification Tree





STRUCTURAL BONDS NEED STIFFNESS AND STRENGTH, SO THE STRUCTURAL ADHESIVES (SHEAR STRENGTH > 5 MPa) ARE ALMOST ALL THERMOSETS. THESE ARE THE MAIN FAMILIES:

EPOXY

- KING OF STRUCTURAL ADHESIVES;
- STRONG;
- STIFF;
- DIMENSIONALLY STABLE;
- EXCELLENT CHEMICAL RESISTANCE;
- AVAILABLE IN ONE-PART (HEAT CURE) AND TWO-PART (ROOM TEMP) FORMULATIONS;
- BRITTLE UNLESS MODIFIED;
- COMMERCIAL EPOXIES ARE TYPICALLY TOUGHENED WITH RUBBER OR HYBRID FILLERS;
- USED IN AEROSPACE COMPOSITE AND METAL BONDS.



MODIFIED ACRYLIC (MMA)

- VERY FAST CURE;
- SERVICE TEMPERATURE 40°C TO 120 °C;
- TOLERATES POORLY PREPARED SURFACES;
- STRONG ODOUR;
- CAN BOND WITHOUT PRIMERS;
- WIDELY USED IN AUTOMOTIVE AND MARINE.



PHENOLIC

- HIGH TEMPERATURE RESISTANCE (TO 180°C);
- BRITTLE;
- LOW PEEL STRENGTH;
- REQUIRES HEAT + PRESSURE TO CURE;
- HISTORICAL NOTE: THE FIRST STRUCTURAL ADHESIVE USED IN AERONAUTICS WAS VINYL-PHENOLIC (REDUX SERIES, UK, WWII).



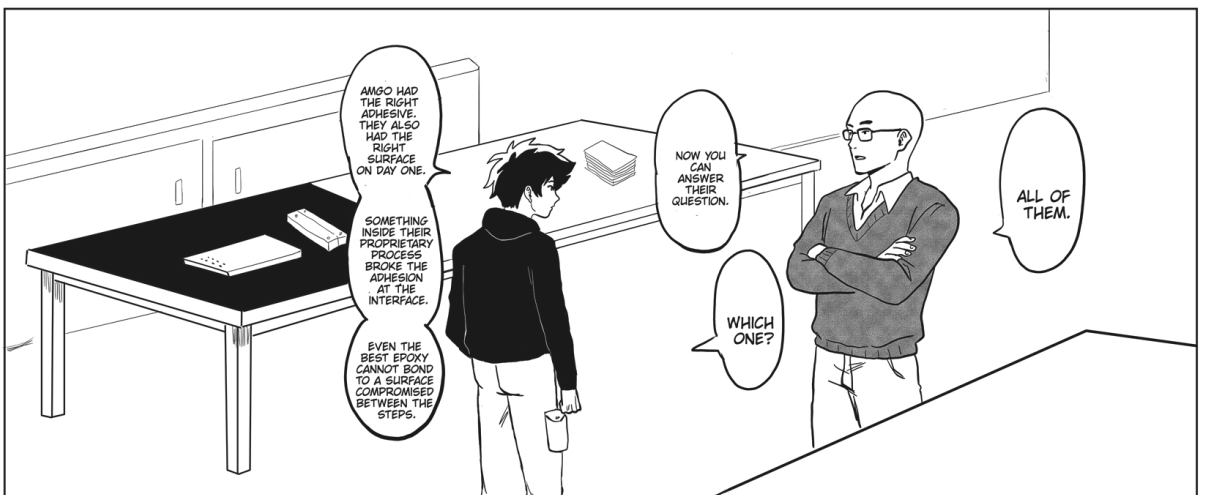
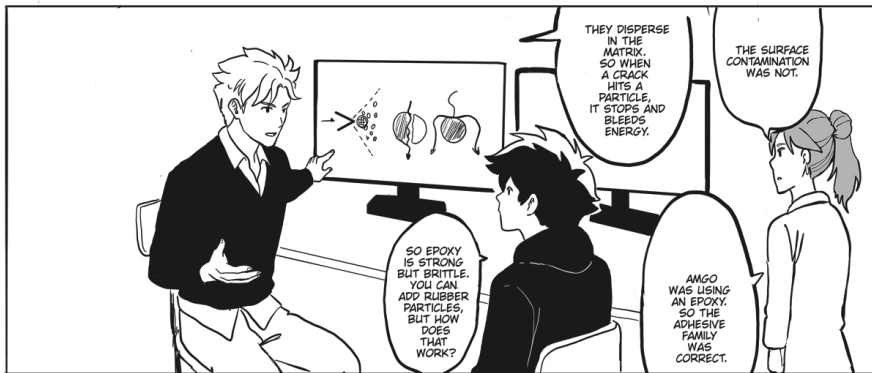
POLYURETHANE

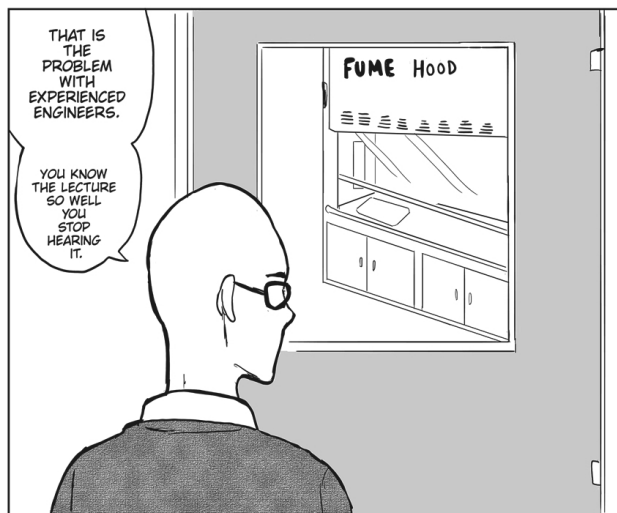
- FLEXIBLE AND DEFORMABLE;
- WIDE RANGE OF STIFFNESS/TOUGHNESS;
- EXCELLENT AT LOW TEMPERATURES;
- PERFORMANCE DROPS QUICKLY AT HIGH TEMPERATURES;
- BONDS SUBSTRATES WITH LOWER SURFACE ENERGY (GLASS, SOME POLYMERS);
- USED IN WINDSCREENS AND VEHICLE BODIES.



AROMATIC

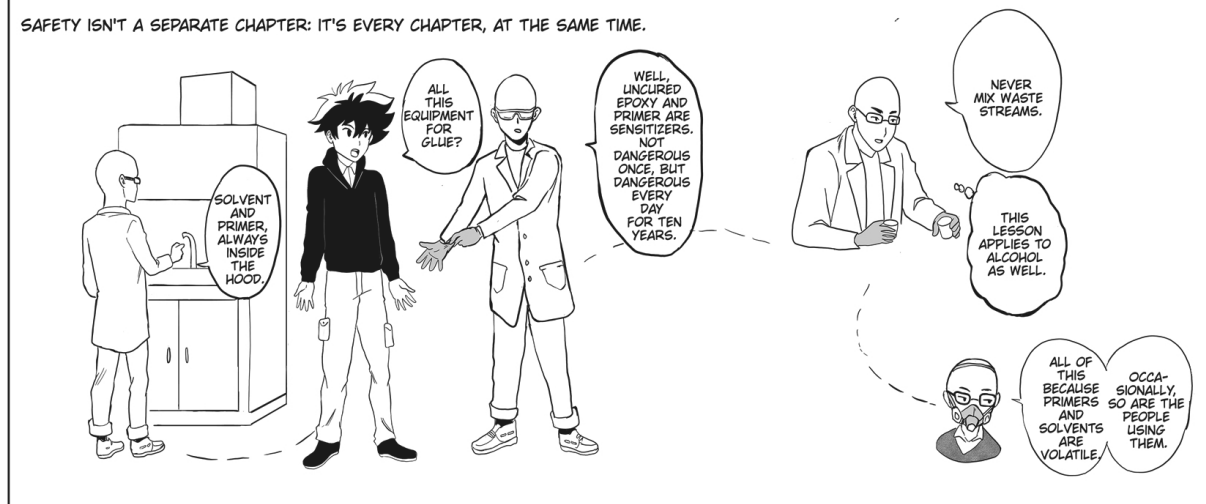
- MAXIMUM TEMPERATURE RESISTANCE (UP TO 280 °C);
- VERY BRITTLE;
- EXPENSIVE;
- FILM ADHESIVES ONLY;
- THE MOST COMMON ARE POLYAMIDES, BISMALEIMIDES AND POLYBENZIMIDAZOLES;
- EXCLUSIVELY AEROSPACE.

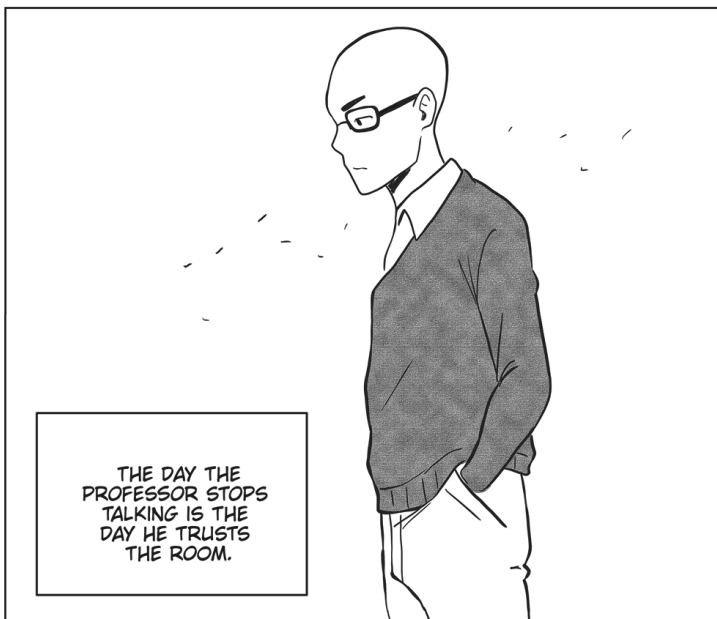
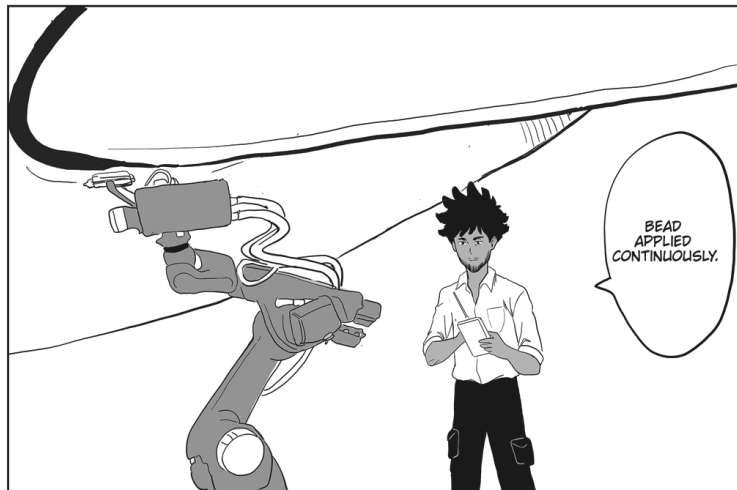




TECHNICAL INSET - HEALTH, SAFETY & ENVIRONMENT

SAFETY ISN'T A SEPARATE CHAPTER: IT'S EVERY CHAPTER, AT THE SAME TIME.







THE UNBREAKABLES - END.

JOVI CONTINUED AT THE
UNBREAKABLES' LAB IN PORTO.
THE AMGO CASE WAS ADDED
TO THE SECOND EDITION OF
THE BOOK "INTRODUCTION TO
ADHESIVE BONDING".

Doing a Master's thesis is a lot of work, and Jovi knows it all too well. At first, he thought everything he needed was in the textbook. However, Professor Leon had other plans.

When AMGO, an aerospace company, reaches out asking for help investigating a mysterious failure in its first fully-bonded primary structure, Jovi's theoretical thesis turns into a hands-on investigation. The textbook doesn't disappear, it just starts showing up exactly when he needs it.

Is AMGO flying too close to the limit? The company's board wants answers, and they're ready to go back to rivets if the problem isn't solved. Can the team find the root cause before it's too late? And can Jovi keep up?

Grab your lab coat. Let's find out.

**ONE MIGHT THINK ACADEMIA
AND INDUSTRY DON'T HAVE MUCH
TO SAY TO EACH OTHER. THIS
STORY SAYS OTHERWISE.**



Also available in e-book format



ISBN: 978-989-930-548-9



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