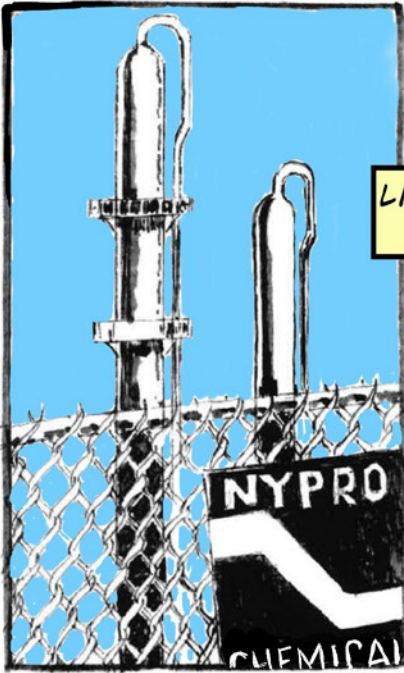


A Graphic Dramatization of the Flixborough Disaster

Ramin Abhari

NYLON YEARS

LINCOLNSHIRE TOWN OF FLIXBOROUGH...



...AND NEARBY CITY OF SCUNTHORPE.



SO WHAT WILL IT BE,
PRETTY GIRLS?

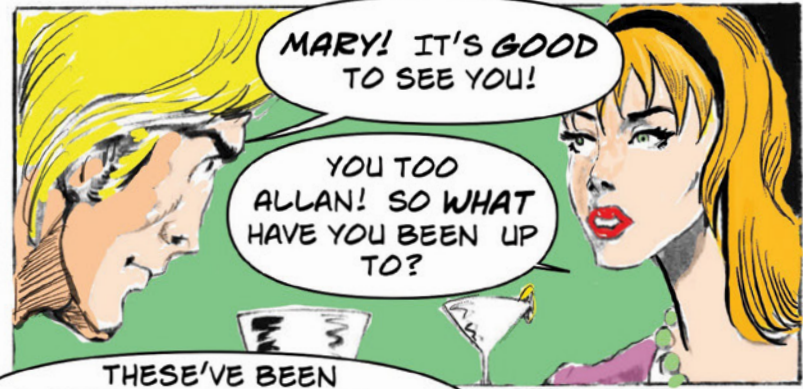
MARY'S HERE
FROM SHEFFIELD AND
WE FEEL LIKE TAKING
CHANCES!

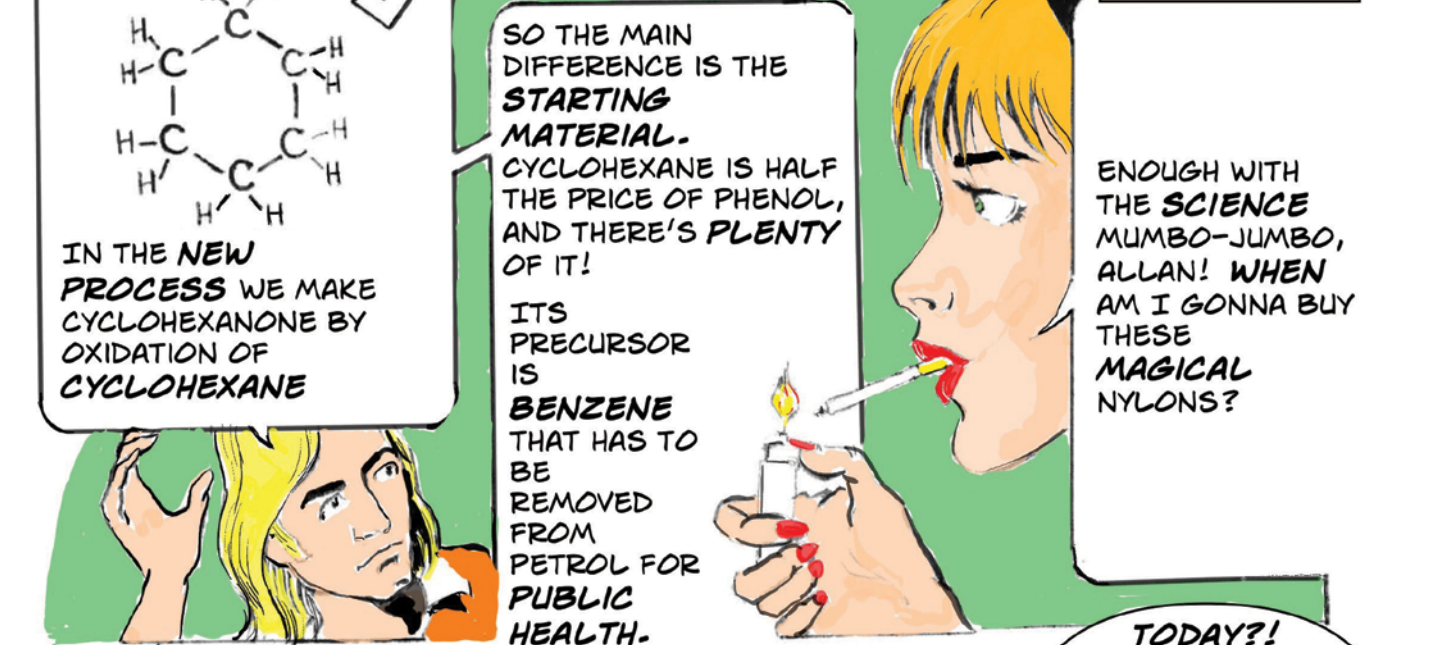
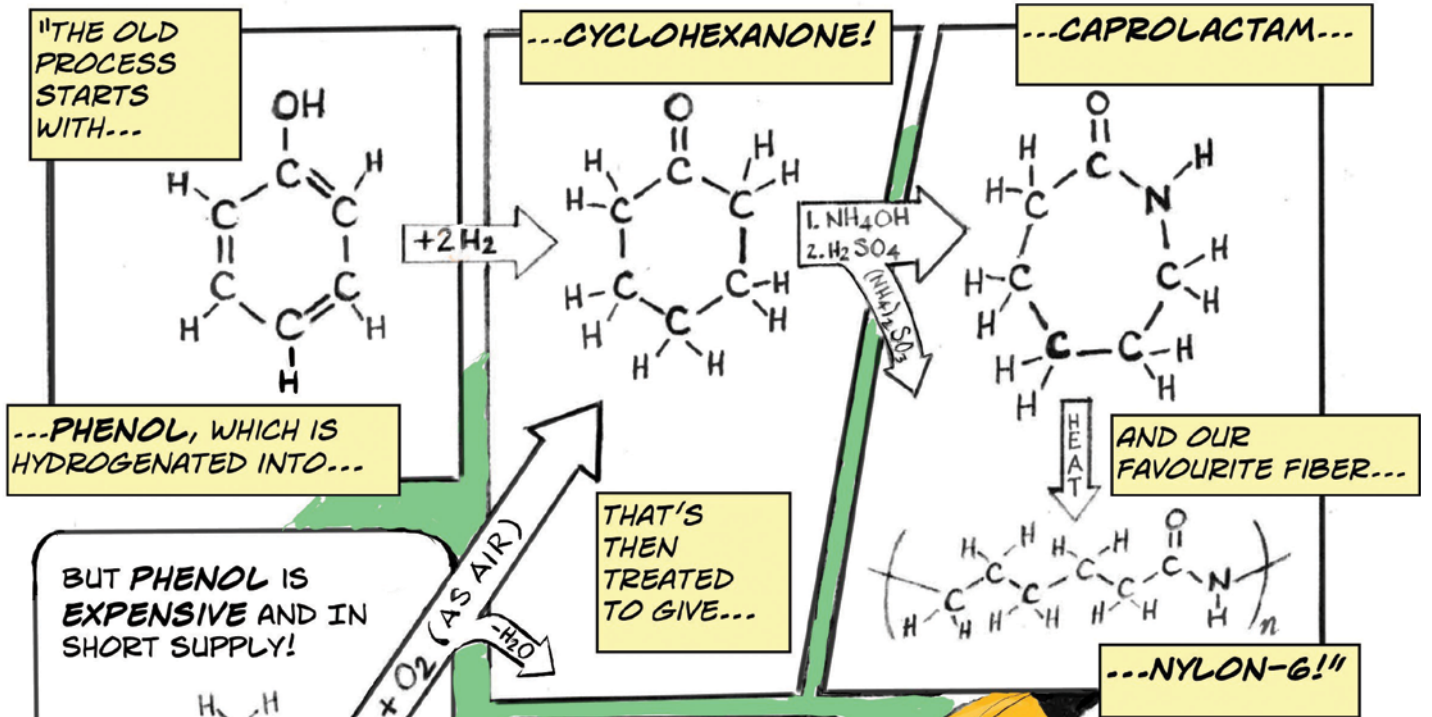
MID APRIL, 1973

SO MAKE US YOUR
SPECIAL COCKTAIL,
NOBBY!



CHAPTER 1. CYCLOHEXANE COCKTAILS





WELL MARY, WE JUST STARTED PRODUCTION AT THE CYCLOX UNIT TODAY!

TODAY?! WELL PLEASE TELL ME MORE ABOUT THIS LUCKY DAY OF YOURS THAT YOU HAPPENED TO SEE ME AFTER SEVEN YEARS AND STARTED PRODUCTION OF LOW-COST NYLON!

OKAY LADS,
WE'VE ALL GONE
OVER THE **STARTUP
PROCEDURE...**

"OUR SHIFT SUPERINTENDENT, **RICK SIMPSON**, WAS AT HIS **BEST** AS A LEADER TODAY! HE HAD JUST RETURNED FROM TRAINING AT D.S.M.'S SMALLER **CYCLOX** UNIT IN **GELEEN, HOLLAND.**"

FIRST, WE
FILL UP EVERYTHING
WITH **CYCLOHEXANE**.
THEN WE GET IT BOILING UP
THE **DISTILLATION
COLUMN** AND PUMP IT
BACK AROUND!

I'M
ON TOP OF IT,
RICK! WE'RE ON
STEP 14, "TURN ON
THE **REACTOR
AGITATORS**"

ALBERT! CHECK OFF
EACH COMPLETED
PROCEDURE STEP AND MAKE
SURE WE **DON'T SKIP**
ANYTHING!

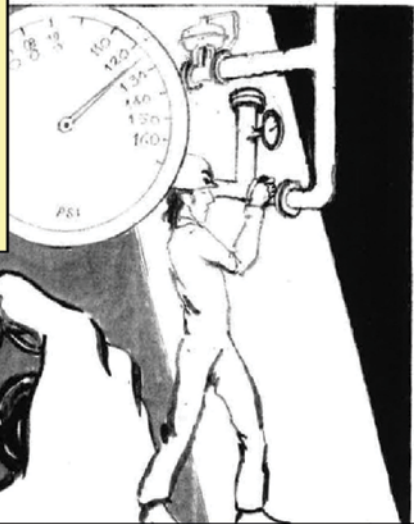
"WE HAVE **SIX** STIRRED
REACTORS IN A ROW,
CONNECTED TO EACH OTHER
BY **OVERFLOW BELLOWS!**
I'D STUDIED THE REACTOR
MECHANICAL DRAWINGS SO
MUCH THAT I FELT I COULD
SEE INSIDE!"

"THOSE ARE THE **ACCORDION-**
LOOKING PIPE CONNECTIONS FOR
THERMAL EXPANSION!"

"WOW **ALLAN**, ARE YOU ALWAYS THIS
PREPARED? AND WHAT ARE
BELLOWS?"

"WE THEN STARTED STEAM
TO THE REACTOR
PREHEATER AS WE GOT THE
DISTILLATION COLUMNS
READY...**BOILING UP ALL THE
CYCLOHEXANE,**
CONDENSING IT, AND
REFLUXING SOME WHILE
PUMPING THE REST BACK TO
THE **REACTORS!**"

"THAT'S WHEN RICK
ASKED OUR FIELD
OPERATOR, **JOHN**
RENDER TO
CLOSE THE
PRESSURE
CONTROL VALVE
BYPASS...



"REACTOR PRESSURE AND TEMPERATURE
CONTROLS WERE NOW IN **AUTOMATIC...**
AND READY FOR THE **CRITICAL NEXT STEP!**"

"OUR NEW OPERATOR, MICHAEL SKELTON, WAS AT THE BOARD!"

YES MICHAEL! THE AIR COMPRESSOR IS ON! OPEN THE AIR SUPPLY VALVES NOW!

CYCLOHEXANE FLOW IS 100 TONS AN HOUR, REACTORS AT 155 C AND 125 PSI GAUGE... NOW? AIR INJECTION?

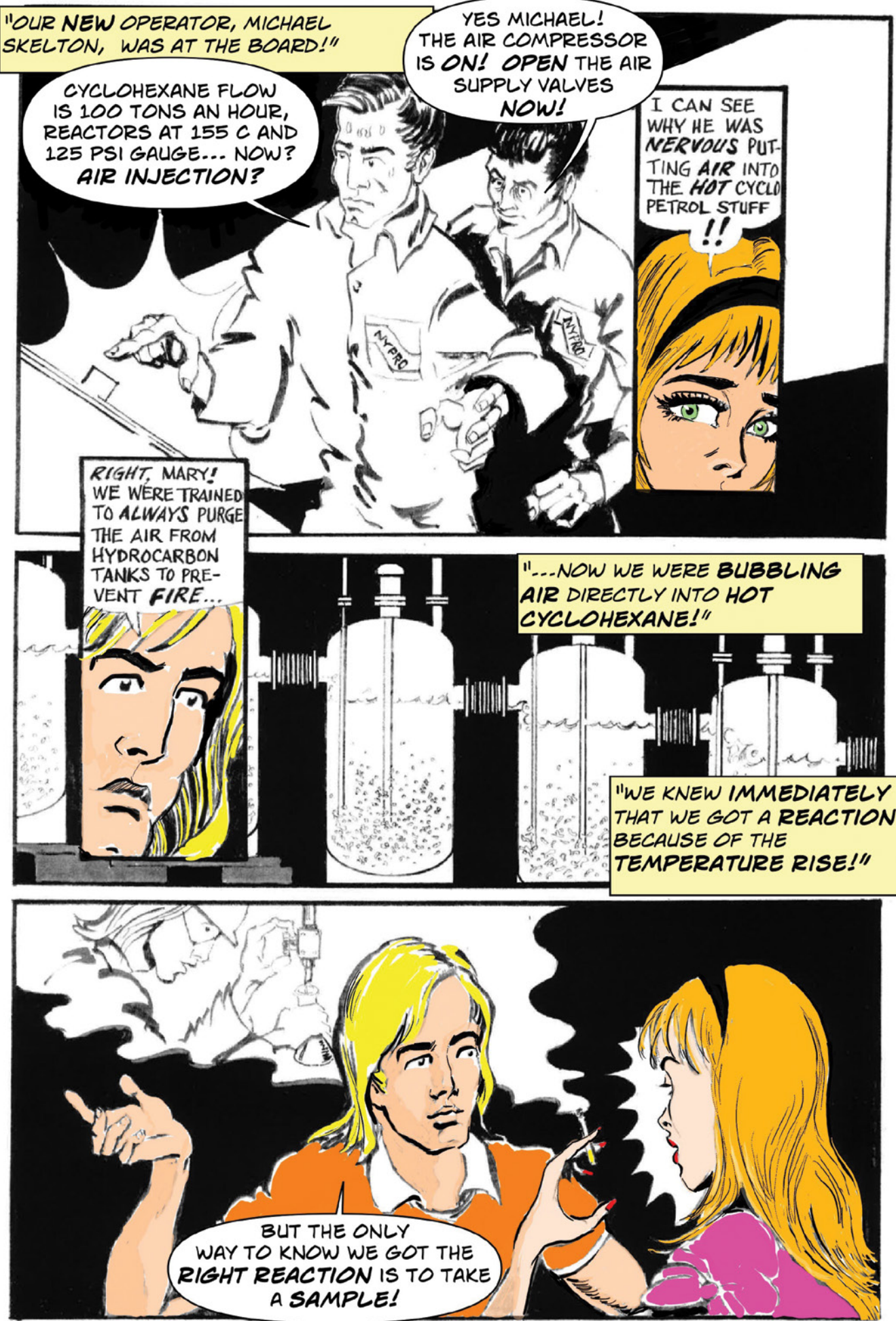
I CAN SEE WHY HE WAS NERVOUS PUTTING AIR INTO THE HOT CYCLO PETROL STUFF !!

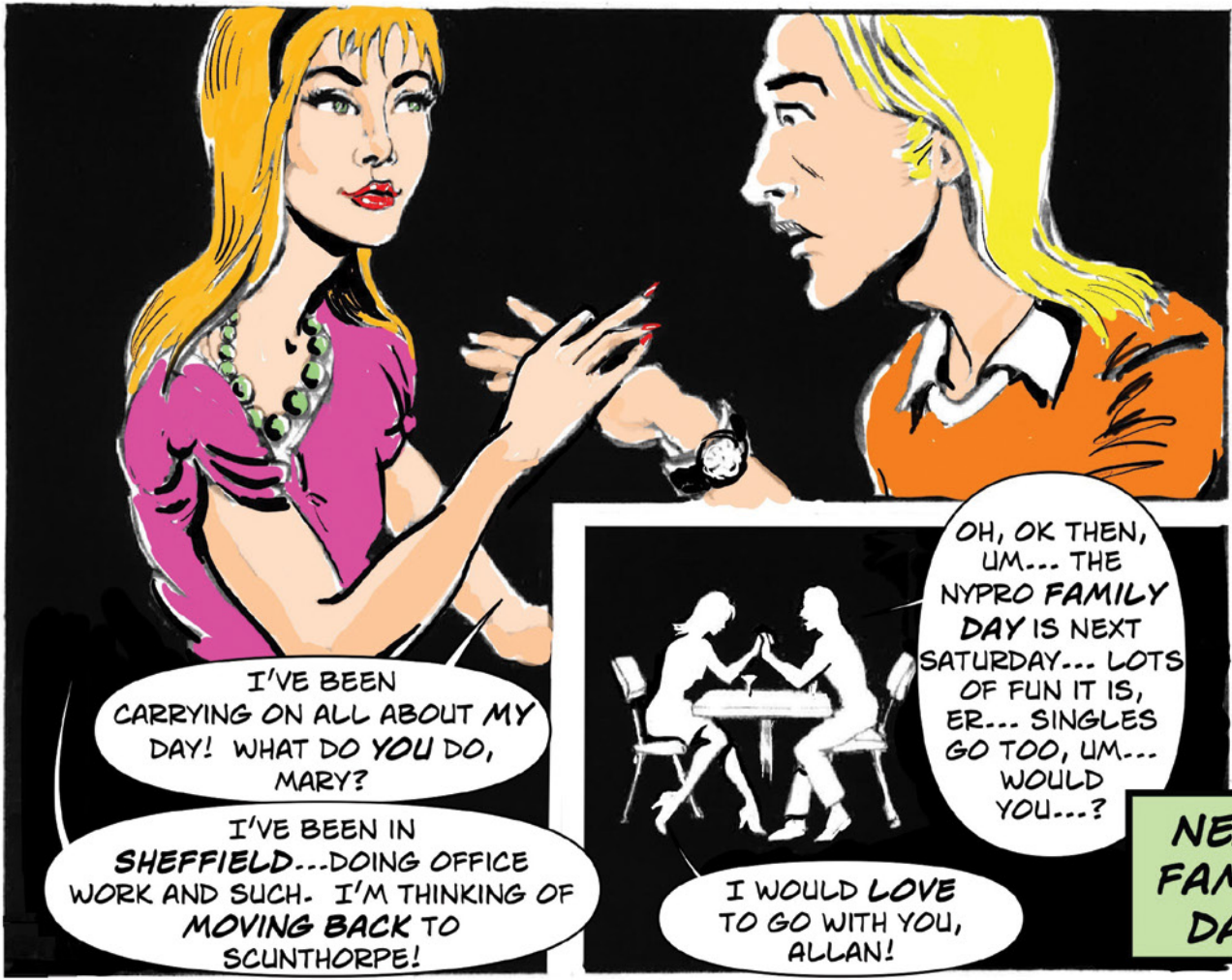
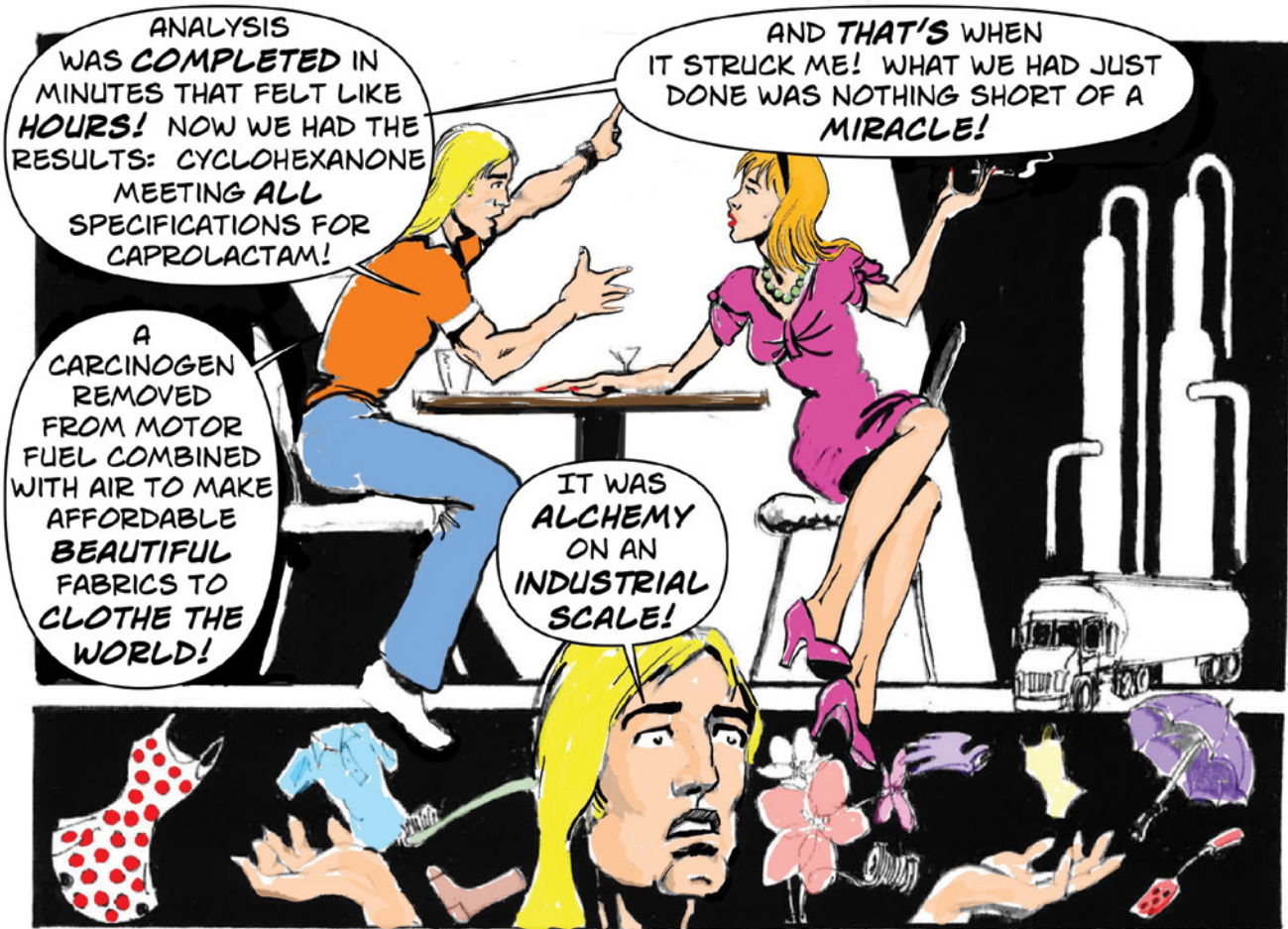
RIGHT, MARY! WE WERE TRAINED TO ALWAYS PURGE THE AIR FROM HYDROCARBON TANKS TO PREVENT FIRE...

"...NOW WE WERE BUBBLING AIR DIRECTLY INTO HOT CYCLOHEXANE!"

"WE KNEW IMMEDIATELY THAT WE GOT A REACTION BECAUSE OF THE TEMPERATURE RISE!"

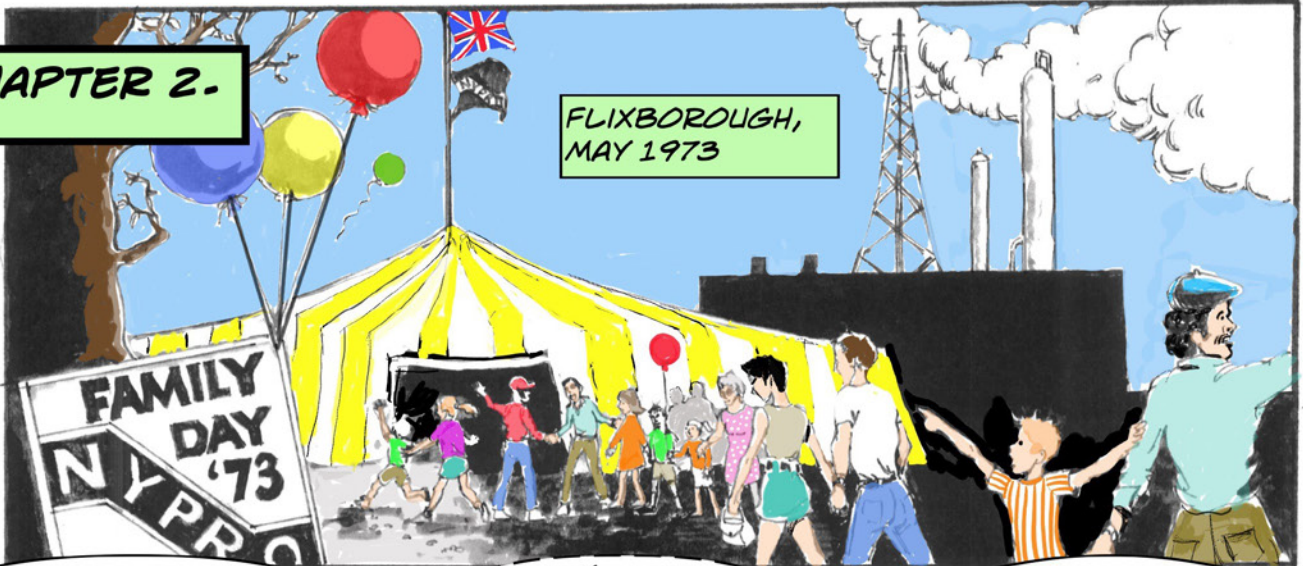
BUT THE ONLY WAY TO KNOW WE GOT THE RIGHT REACTION IS TO TAKE A SAMPLE!





CHAPTER 2.

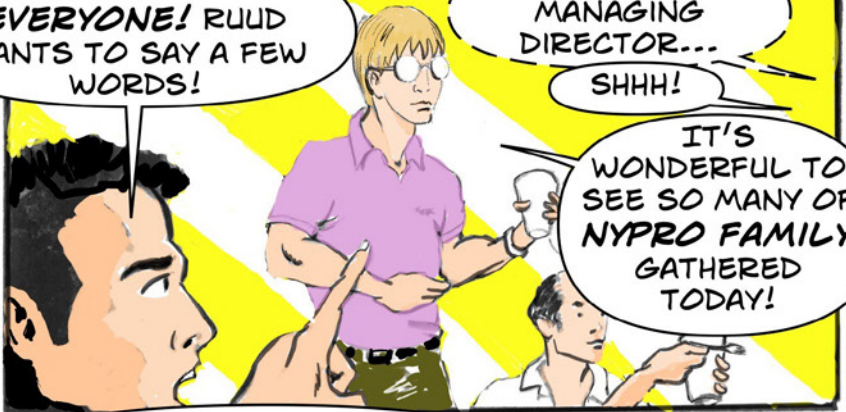
FLIXBOROUGH,
MAY 1973



QUIET EVERYONE! RUUD WANTS TO SAY A FEW WORDS!

HE'S THE MANAGING DIRECTOR... SHHH!

OUR COMPANY WAS FORMED NINE YEARS AGO, AT A TIME WHEN THE DUPONT-I.C.I. VENTURE HELD THE NYLON MONOPOLY IN U.K.

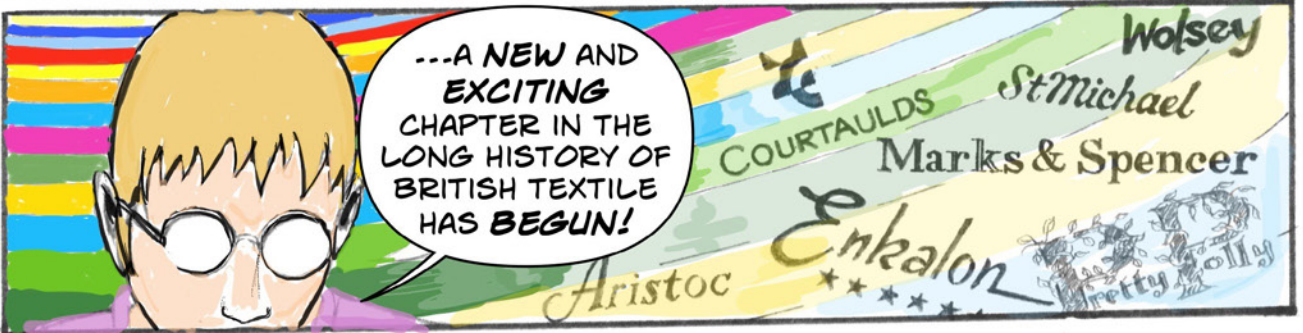


IT'S WONDERFUL TO SEE SO MANY OF NYPRO FAMILY GATHERED TODAY!



HOW COULD THE ONCE VIBRANT BRITISH TEXTILE INDUSTRY REMAIN COMPETITIVE WHEN IT COULD ONLY PURCHASE NYLON FROM ONE SUPPLIER?!

NOW, THANKS TO NYPRO...



...A NEW AND EXCITING CHAPTER IN THE LONG HISTORY OF BRITISH TEXTILE HAS **BEGUN!**

NYPRO CONTINUES

TO **GROW** IN THE COMPETITIVE **SYNTHETIC FIBERS** MARKET THROUGH INNOVATIONS LIKE **CYCLOX**. THIS TECHNOLOGY IS NEAR AND DEAR TO ME **PERSONALLY**. IT WAS THE FIRST PROJECT I WORKED ON WHEN I JOINED **D.S.M.** AFTER GRADUATION FROM DELFT.

SO TO SEE THE **LARGEST** **CYCLOX** UNIT IN THE WORLD RIGHT HERE IN FLIXBOROUGH IS PARTICULARLY **REWARDING**.

NOW I WOULD LIKE TO CHALLENGE OUR ENGINEERS AND OPERATING STAFF TO WORK TOGETHER AND INCREASE PRODUCTION THERE TO DESIGN CAPACITY BEFORE OUR GRAND OPENING NEXT MONTH.

MY FELLOW **NYPRONIANS!** I WANT TO CLOSE BY THANKING EACH OF YOU FOR YOUR HARD WORK AND **LOYALTY!**

OK ALL! GAMES START AFTER LUNCH!

WE HAVE LOTS OF ACTIVITIES FOR KIDS OF ALL AGES—INCLUDING THE NYLON-ROPE-TUG-OF-WAR AND THE NYLON-SCARF-THREE-LEGGED RACE!

THERE IS **NOWHERE** IN THE WORLD I'D RATHER BE THAN RIGHT HERE IN **FLIXBOROUGH!**

CLAP! CLAP! CLAP!



RUUD GAVE SUCH AN **INSPIRATIONAL** SPEECH! I'M SURE IT MADE EVERYONE PROUD TO BE WORKING AT NYPRO!

I GUESS CORPORATE **BULLSHIT** SOUNDS BETTER WITH A DUTCH ACCENT!

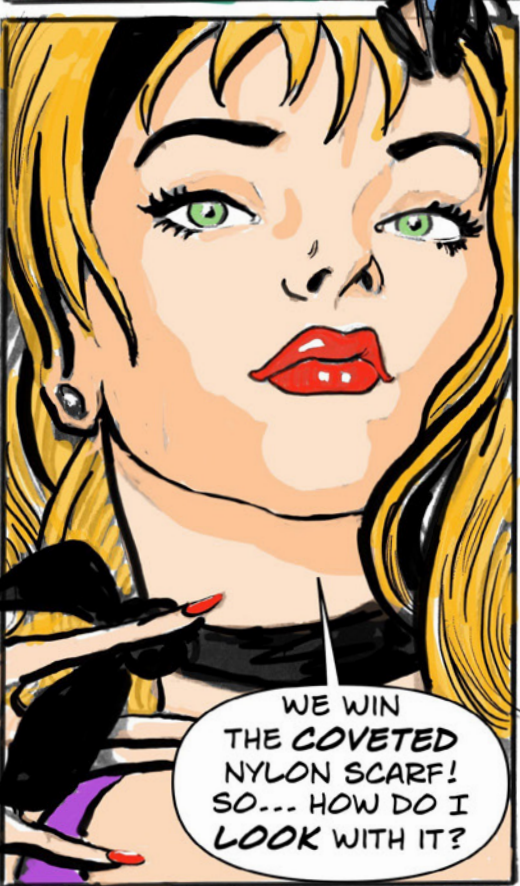
HAHA! BEAUTIFUL AND FUNNY! ALLAN, PLEASE **INTRODUCE** US TO YOUR FRIEND!

OH **SORRY** EVERYONE! THIS IS **MARY!** MARY, THESE ARE SOME OF THE GUYS WHO WORK WITH ME IN THE "**C-SHIFT**"— KEITH, ROLAND, JOHN,...

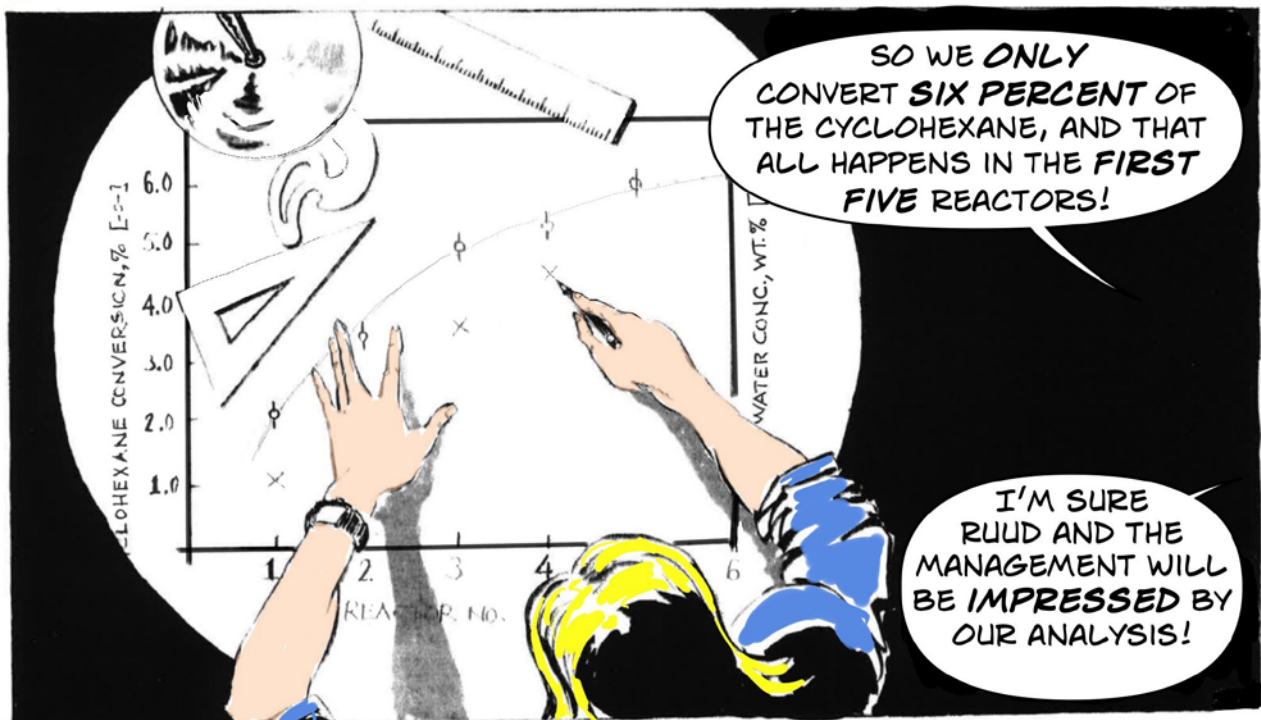
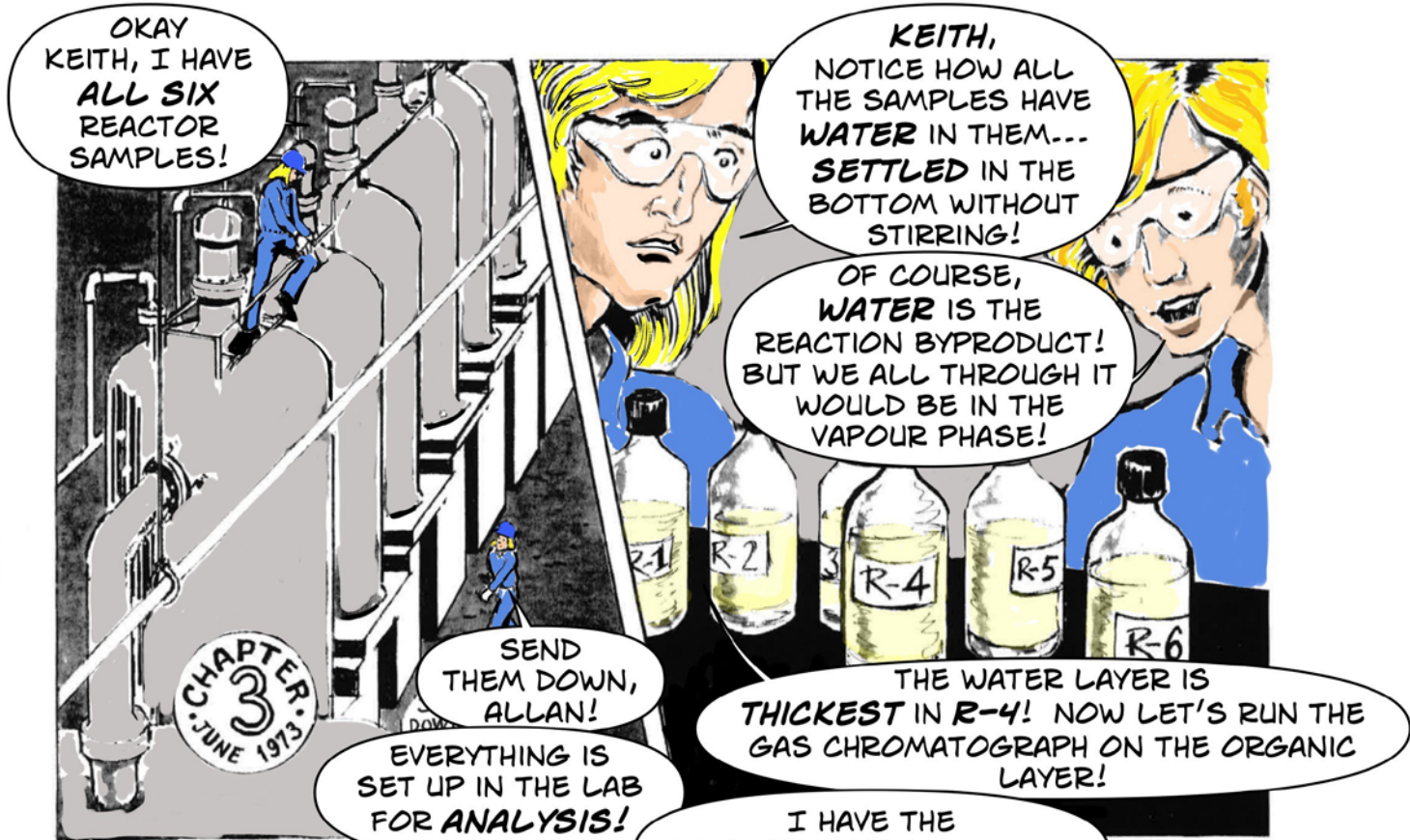
ALLAN, WHAT DO YO SAY WE ACCEPT RUDD'S **CHALLENGE** AND FIND A WAY TO SQUEEZE MORE PRODUCT OUT OF THE **REACTORS!** I HAVE SOME IDEAS...

NO TALK OF WORK ON **FAMILY DAY!** LET'S GET READY FOR THE TUG-OF-WAR!

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**NEXT:
WATER IN THE REACTORS!**



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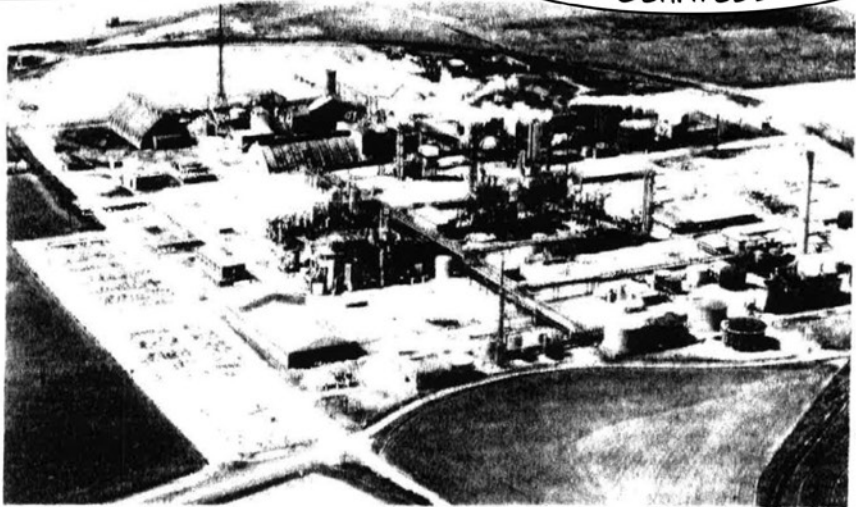
GOOD JOB WITH THE REACTOR REPORT, LADS! BUT THE D.S.M. ANALYSTS HAVE NOW CONCLUDED THAT...

...EVEN AT 6% CONVERSION AND 50,000 TON/YEAR OUTPUT, THIS IS THE LOWEST COST NYLON PRODUCTION PLATFORM WITH THE HIGHEST RETURN ON CAPITAL. NOTHING OTHER THAN AN UNLIKELY RISE IN OIL PRICES WILL CHANGE IT!

THE GRAND OPENING NEXT WEEK IS A RECOGNITION OF THAT!

ALL THE BIG SHOTS WILL BE HERE! SO LET'S MAKE SURE EVERYTHING'S CLEAN AND WE'RE ALL WELL-BEHAVED!

WHO WOULD'VE GUESSED? A REACTION THAT ONLY GOES TO 6% COMPLETION—WITH 94% DISTILLED AND RECYCLED—WOULD BE MOST ECONOMIC!



Caprolactam capacity at Nypro's Flixborough plant is now 75,000 metric tons

Just last month, DSM executives officiated at the opening of a 50,000 metric ton-a-year facility at Flixborough, England. That plant is operated by Nypro, Ltd., a company in which DSM has a 55% interest and the U.K.'s National Coal Board 45%. The new unit raises total caprolactam capacity at Flixborough, Britain's only plant, to 75,000 metric tons.

The new plants at Augusta and Flixborough use benzene-derived cyclohexane which is air oxidized to cyclohexanone under carefully controlled conditions. Previously, the cyclohexanone feedstock was made at Flixborough by catalytic hydrogenation of phenol.

July 23, 1973 C&EN 7

THAT'S THE TRIUMPH OF ENGINEERING OVER CHEMISTRY!

IT'S LIKE I'M LIVING A DREAM! I FINALLY HAVE MY DREAM CAR, DREAM JOB, AND DREAM GIRL!

LOOK OUT WORLD! I MADE IT TO NUMBER THREE!

BEEP! BEEP!

ALLAN IS HERE!

HE'S PICKING ME UP IN HIS NEW CAR!



NEXT: A CRUDE AWAKENING!

CHAPTER 4
AUTUMN of '73

IN BREAKING NEWS, THE ARMIES OF EGYPT AND SYRIA HAVE LAUNCHED A COORDINATED ATTACK ON ISRAELI FORCES IN THE SINAI AND THE GOLAN HEIGHTS...

IN OTHER NEWS, NEGOTIATIONS BETWEEN THE NATIONAL COAL BOARD AND THE MINERS HAVE BROKEN DOWN AND THE "MINIMUM WORK" STRIKE CONTINUES!



RESPONDING TO U.S. MILITARY ASSISTANCE TO ISRAEL IN THE CURRENT WAR, ARAB OIL EXPORTERS HAVE STOPPED ALL SHIPMENTS OF CRUDE OIL TO SELECTED WESTERN NATIONS, INCLUDING BRITAIN. AN ANNOUNCEMENT FROM THE PRIME MINISTER IS EXPECTED.

AT THIS TIME OF NATIONAL ENERGY EMERGENCY, OUR COAL-FIRED POWER PLANTS MUST OPERATE AT INCREASED RATES TO MAKE UP FOR REDUCTION IN DIESEL-FUELED GENERATING CAPACITY!

WE EXPECT OUR COAL MINERS TO FULFILL THEIR DUTY AND NOT GIVE IN TO RADICAL ELEMENTS WHO PUT CLASS-STRUGGLE AHEAD OF NATIONAL INTEREST!

9 O'CLOCK NEWS



RICHARD BAKER



MR. HEATH AND HIS TORY APPOINTEES ON THE N.C.B. ARE POLITICISING A PAY DISPUTE! TO THAT WE SAY, NO INCREASE IN COAL PRODUCTION WITHOUT A PAY RAISE!

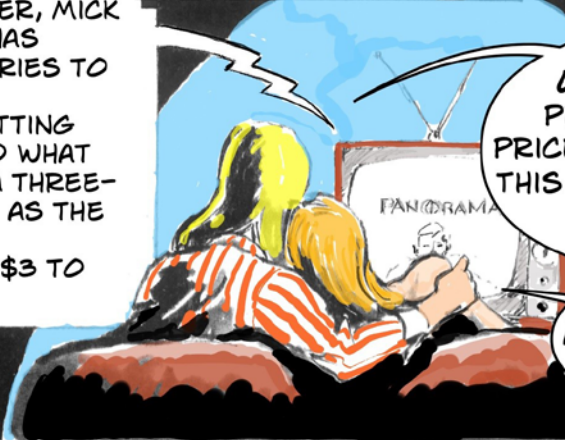
MR. MCGAHEY, YOUR RESPONSE TO THE P.M.?



IN THE LATEST PHASE OF THE BATTLE-OF-WILLS BETWEEN TED HEATH AND THE MINERS' UNION LEADER, MICK MCGAHEY, THE P.M. HAS ORDERED ALL FACTORIES TO REDUCE POWER CONSUMPTION BY CUTTING BACK OPERATIONS TO WHAT IS EXPECTED TO BE A THREE-DAY WEEK! AND THIS AS THE PRICE OF OIL HAS SKYROCKETED FROM \$3 TO \$12 A BARREL!

UNPRECEDENTEDLY HIGH PETROCHEMICAL FEEDSTOCK PRICES AND FORCED POWER-CUTS. THIS IS GOING TO BE A TERRIBLE WINTER, MARY.

OH MY! HOW WILL WE EVER STAY WARM?!



SIX REACTORS SHAKEN, NOT STIRRED!

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NOVEMBER 1973.

CHAPTER 5

RUUD, OUR BACK-UP GENERATORS CAN SUPPLY 70% OF THE UNIT'S POWER. WE'LL NEED AN ADDITIONAL GENERATOR TO BE COMPLETELY OFF THE GRID!

THERE'S NO WAY WE CAN GET A NEW GENERATOR IN TIME...

SO WE NEED TO CUT ELECTRICITY BY 30%. THAT'S HOW MUCH GOES TO POWER THE AGITATORS.

I'LL BET A BOTTLE OF BORDEAUX WE CAN RUN THE REACTORS WITH AGITATORS OFF. THE AIR DOES PLENTY OF MIXING ALONE!

WELL... LET'S TEST THAT HYPOTHESIS.

I'D REALLY HATE TO CHANGE OPERATIONS JUST TO GET AROUND THIS "3-DAY-WEEK" NONE SENSE!

I AGREE RICK! ESPECIALLY WHEN THE UNIT IS RUNNING SO SMOOTHLY!

HELLO? OH HI RUUD!

YES WE'LL TAKE A SAMPLE AND HAVE THE LAB CALL YOU.

COME IN JOHN- MEET ME IN THE MOTOR CONTROL CENTER IN 5 MINUTES.

BLOODY HELL!

RRRING!

CLICK!

SHOOT!

RUN WITH NO AGITATORS?!

YES I KNOW THE AIR AGITATES THE REACTORS...

MMMMMMMM

EEEEEOO

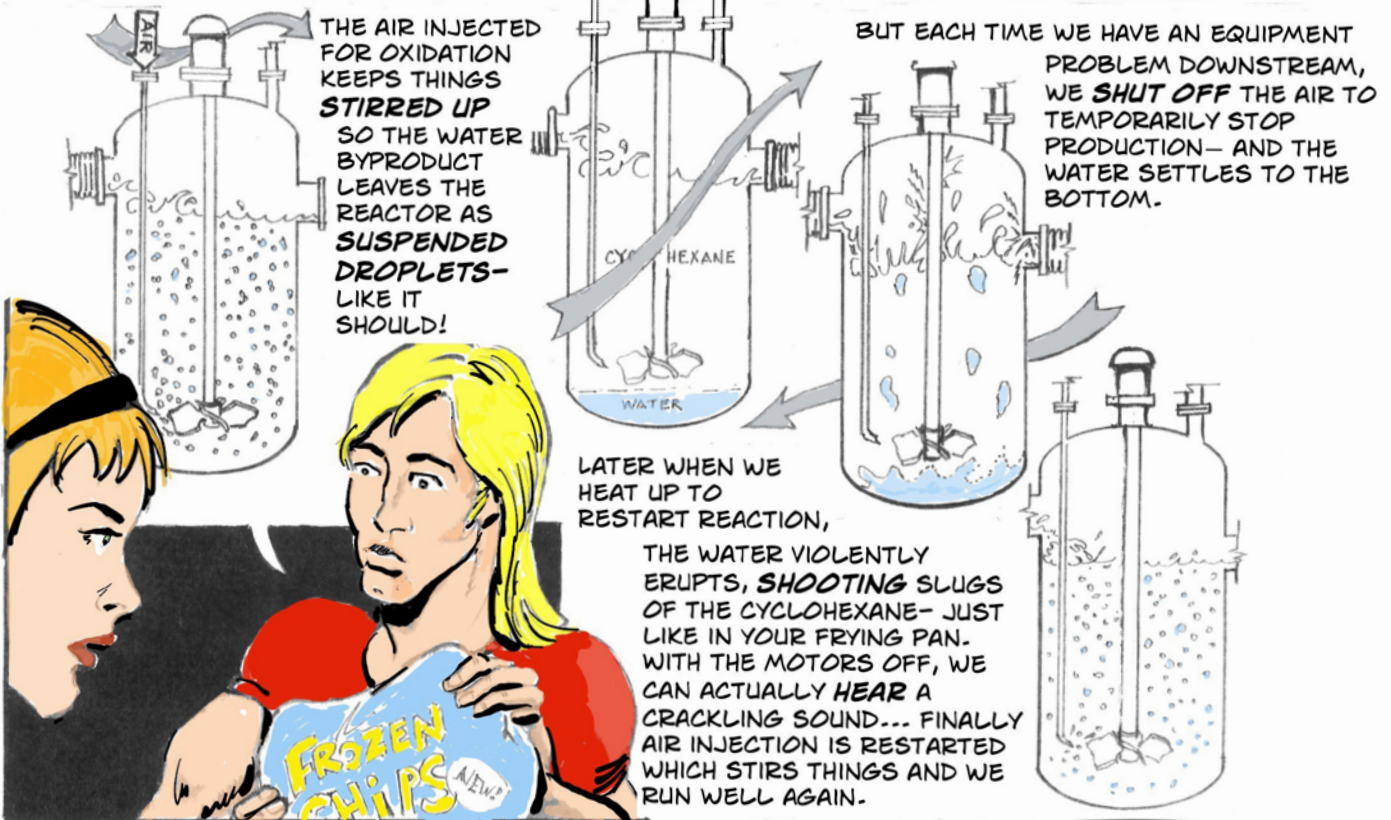
CLANK!

CYCLOHEXANE
CYCLOHEXANONE
CYCLOHEXANOL

HAHA!
WE'RE OFF THE GRID, GENTS! SURE, OUR MARGINS ARE SQUEEZED WITH HIGH BENZENE PRICES- BUT WE'LL MEET OUR PRODUCTION TARGETS...

MR SELMAN, WE'RE GETTING THE SAME REACTOR EFFLUENT COMPOSITION WITHOUT AGITATION AS WE WERE GETTING BEFORE WITH IT ON!

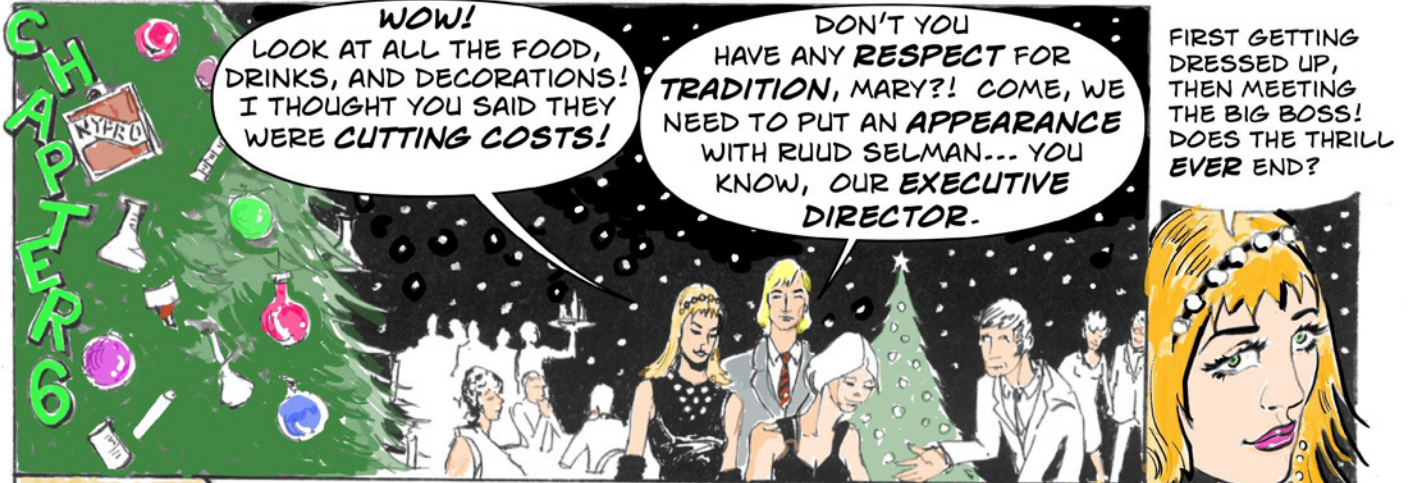
...AND I'LL TAKE A '71 VINTAGE IF YOU PLEASE!



NEXT:

You are invited to the 1973
Nypro Chemical Co.

Christmas PARTY
FOOD • DRINKS • LIVE MUSIC • DANCING • FUN

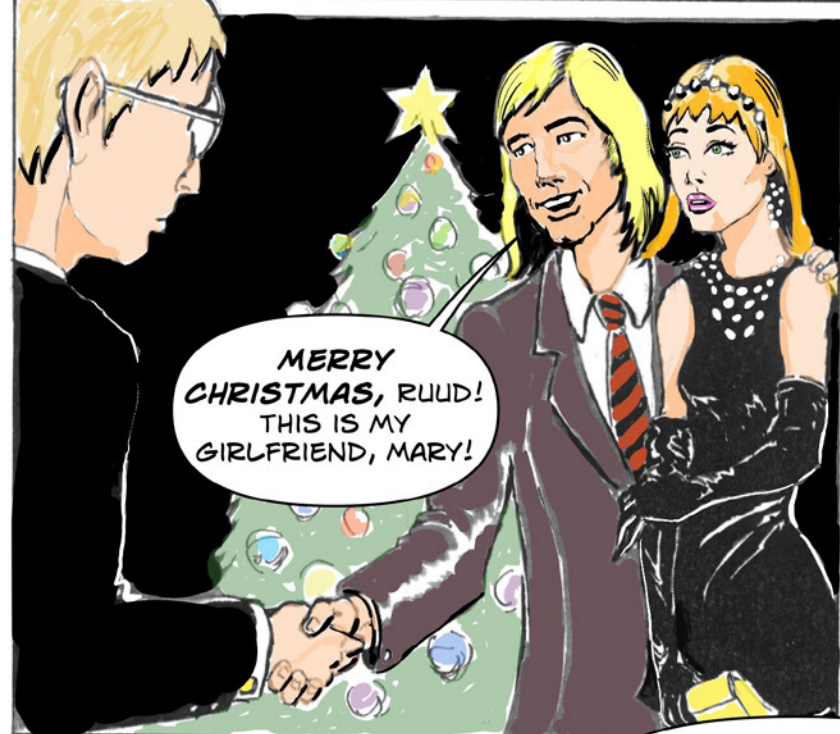


CHAPTER 6

WOW!
LOOK AT ALL THE FOOD,
DRINKS, AND DECORATIONS!
I THOUGHT YOU SAID THEY
WERE **CUTTING COSTS!**

DON'T YOU
HAVE ANY RESPECT FOR
TRADITION, MARY?! COME, WE
NEED TO PUT AN **APPEARANCE**
WITH **RUUD SELMAN...** YOU
KNOW, OUR **EXECUTIVE**
DIRECTOR.

FIRST GETTING
DRESSED UP,
THEN MEETING
THE **BIG BOSS!**
DOES THE **THRILL**
EVER END?



MERRY
CHRISTMAS, RUUD!
THIS IS MY
GIRLFRIEND, **MARY!**



VORLIK
KERSTFEST!
YOU CAN
SPEAK **DUTCH!**

I'M
IMPRESSED!



LET'S GO SIT
NEXT
TO **GEOFF** AND HIS
GIRLFRIEND.



ALLAN!
THERE WAS A
CYCLOHEXANE LEAK
FROM **REACTOR 4!** THE
A-SHIFT HAD TO SPRAY
WATER TO STOP THE
LEAK!

WE NEED TO
TALK, **KEITH!** I THINK
IT'S RELATED TO
RUNNING **WITHOUT**
AGITATION!



ALL **ALLAN** TALKS
'BOUT IS **WORK...** I KNOW
ALL ABOUT **CYCLOHEXANE**
OXIDATION!

ALL **GEOFF**
TALKS ABOUT IS
FOOTBALL! I KNOW
EVERYTHING ABOUT
LIVERPOOL F.C.!

HEY, IT LOOKS LIKE
RUUD IS GOING TO
INTRODUCE THE **BAND!**

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GOOD EVENING NYPRONIANS!
BEFORE I INTRODUCE THE BAND, I'D
LIKE TO SAY A FEW WORDS ABOUT
THE STATE OF OUR BUSINESS.

YOU ALL KNOW THAT THIS YEAR'S
"OIL SHOCK" HAS THROWN OUR
INDUSTRY OFF THE TRACKS OF
PROFITABILITY. SO WE NEED TO BE
VIGILANT IN MANAGING EXPENSES
AND SEEK CREATIVE **LOW-COST**
SOLUTIONS TO OPERATIONAL
ISSUES.



BUT I ALSO WANT TO **ASSURE**
YOU THAT OUR FUTURE IS
BRIGHT! WE HAVE AN ADVANCED
PROCESS TECHNOLOGY FOR
LOW-COST PRODUCTION AND ARE
WELL-POSITIONED TO COMPETE
IN A CYCLICAL MARKET!

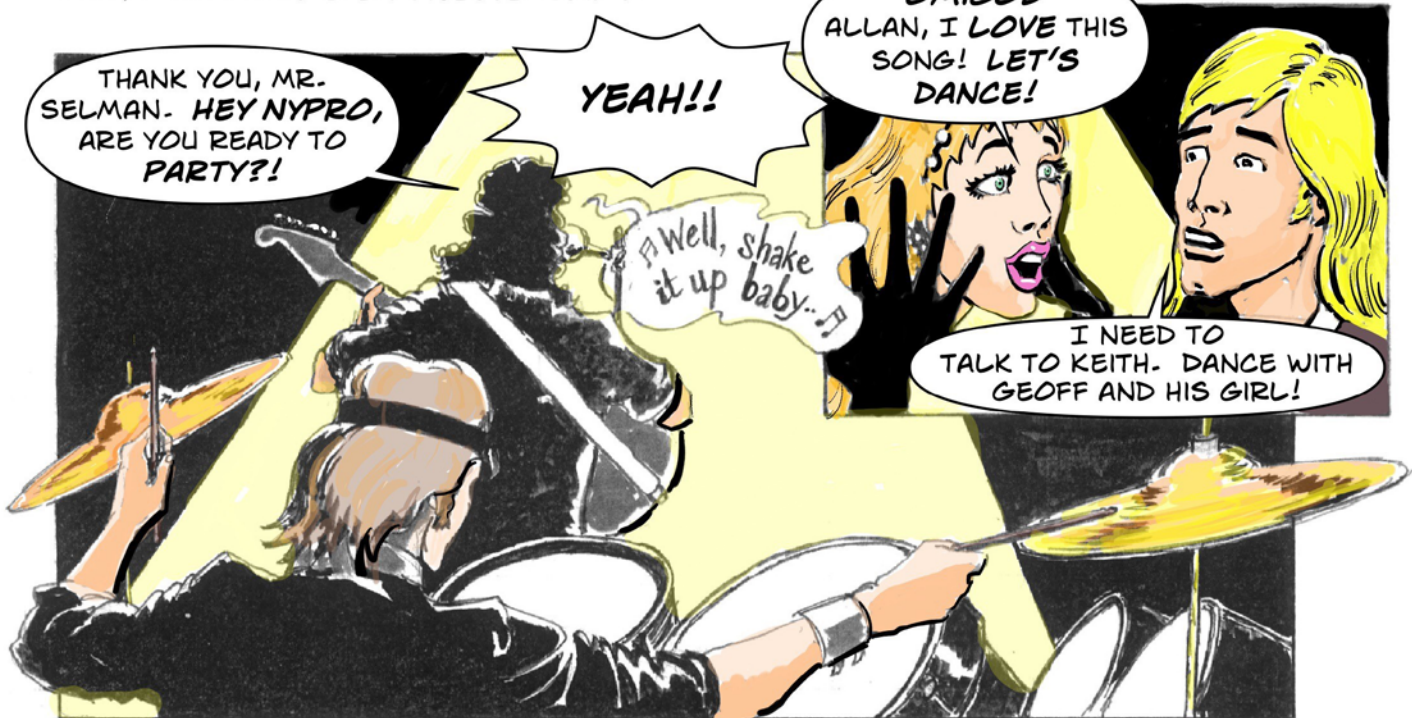


OIL FROM THE **NORTH SEA** WILL
SOON FREE THE U.K. REFINING
AND PETROCHEMICAL INDUSTRIES
FROM IMPORTS! AND **NYPRO**
WILL BE IN A PARTICULARLY
ADVANTAGEOUS POSITION!

WITH THAT, I WISH YOU AND YOUR
FAMILIES A **MERRY CHRISTMAS**
AND A **SUCCESSFUL 1974!**



AND NOW, LADIES AND GENTLEMEN, THE **HOTTEST**
COVER BAND IN LINCOLNSHIRE... WITHOUT FURTHER
ADO, HERE IS... **POLYTHENE JAM!**



THANK YOU, MR. SELMAN. **HEY NYPRO,**
ARE YOU READY TO
PARTY?!

YEAH!!

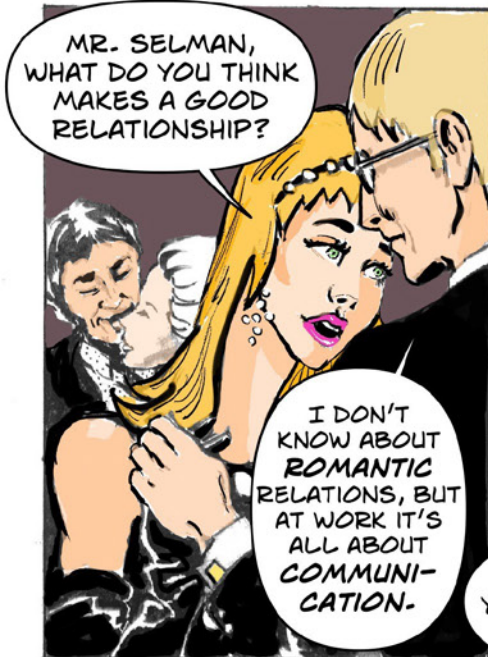
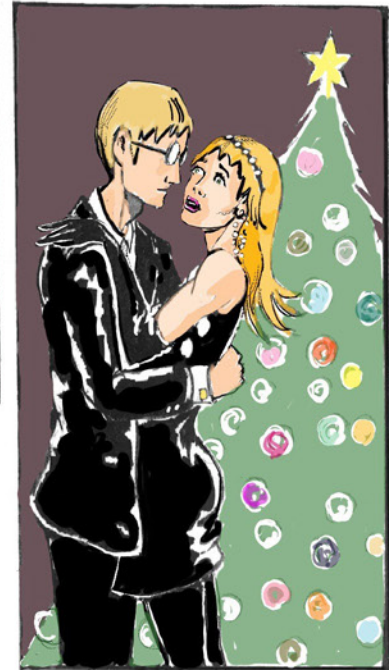
OMIGOD
ALLAN, I LOVE THIS
SONG! **LET'S**
DANCE!

Well, shake
it up baby..!!

I NEED TO
TALK TO KEITH. **DANCE** WITH
GEOFF AND HIS GIRL!



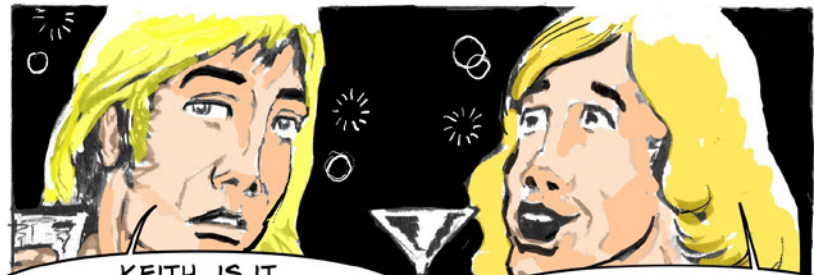
*I look at you all see
the love there
that's sleeping,
While my guitar
gently weeps.
I look at the floor
and I see
it needs sweeping,
Still my guitar
gently weeps.*



MR. SELMAN,
WHAT DO YOU THINK
MAKES A GOOD
RELATIONSHIP?

I DON'T
KNOW ABOUT
ROMANTIC
RELATIONS, BUT
AT WORK IT'S
ALL ABOUT
COMMUNI-
CATION.

*I don't know why
nobody told you
How to unfold your love.
I don't know how
someone controlled you
They bought and sold you.*



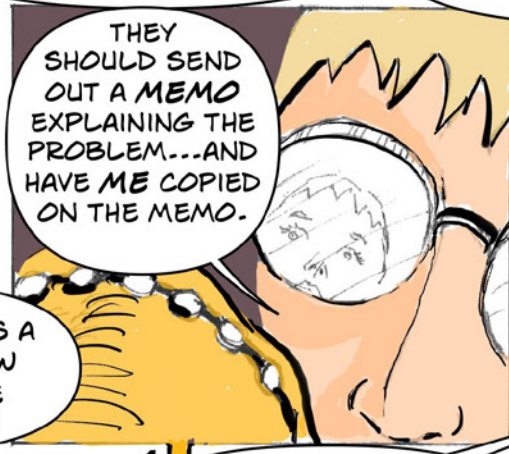
KEITH, IS IT
NORMAL FOR THE BOSS OF
YOUR BOSS'S BOSS TO SLOW-
DANCE WITH YOUR
GIRLFRIEND?

OF COURSE!
IT'S VERY
CONTINENTAL...SHOWS YOU'RE
PART OF THE CORPORATE
FAMILY!

*I look at the
World and
I notice it's
turning,
While my
guitar gently
weeps.
With every
mistake we
should surely
be learning;
Still my guitar
gently weeps.*



AND WHEN
AN EMPLOYEE SEES A
PROBLEM... HOW
SHOULD THAT BE
COMMUNICATED?



THEY
SHOULD SEND
OUT A MEMO
EXPLAINING THE
PROBLEM...AND
HAVE ME COPIED
ON THE MEMO.

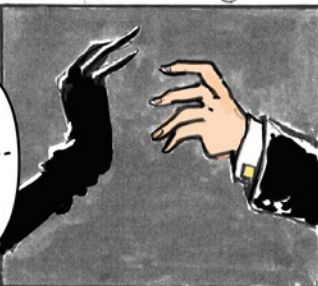
HEY, IT LOOKS LIKE
I'M GOING TO BE
THE DESIGNATED
DRIVER FOR THE
MOST HANDSOME
MAN AT THE PARTY!



I CAN SEE
WHY ALLAN
ADMIRE'S
YOU, RUUD.

TAKE
CARE OF
HIM MARY...
HE HAS POTEN-
TIAL.

*I don't know how
you were diverted...
No one alerted you.*

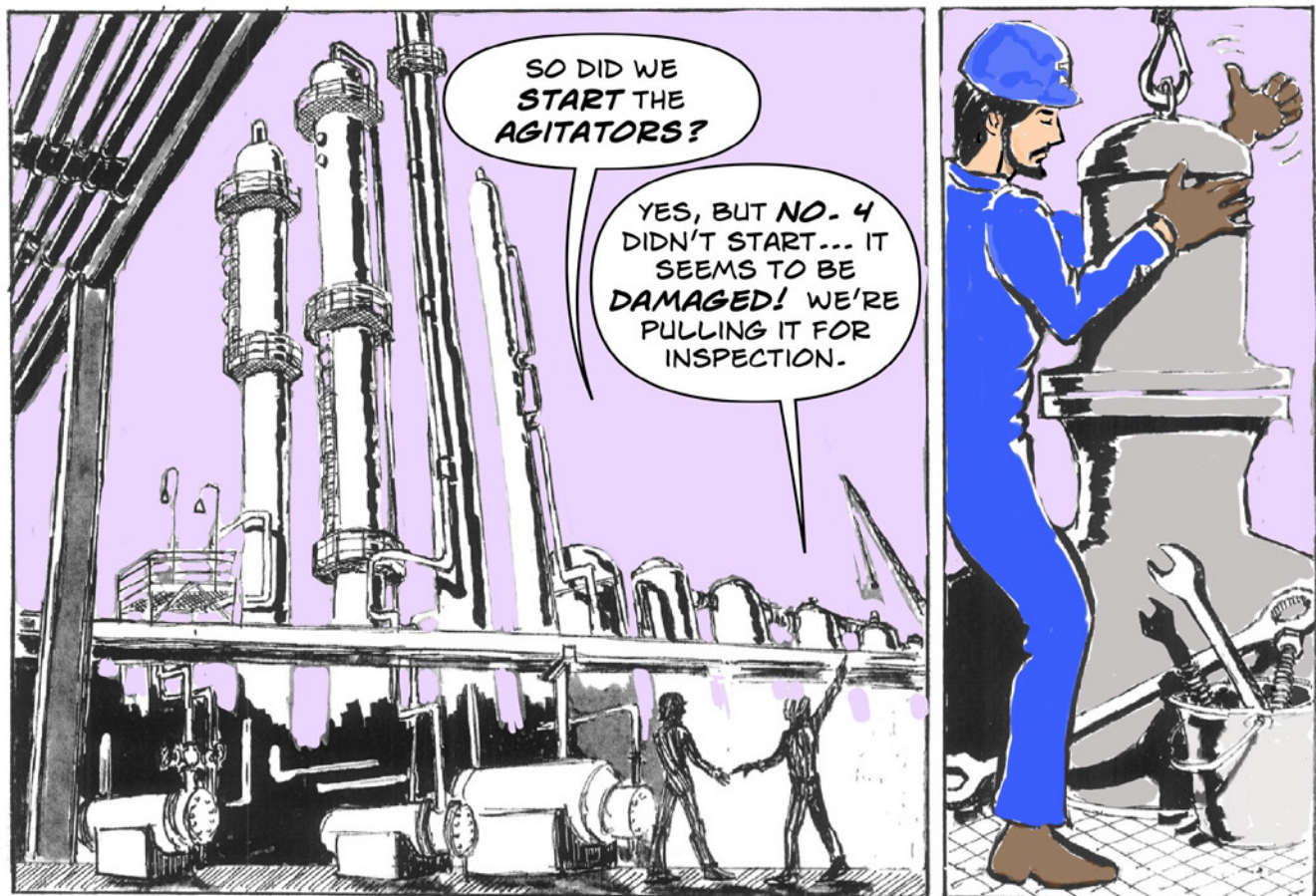
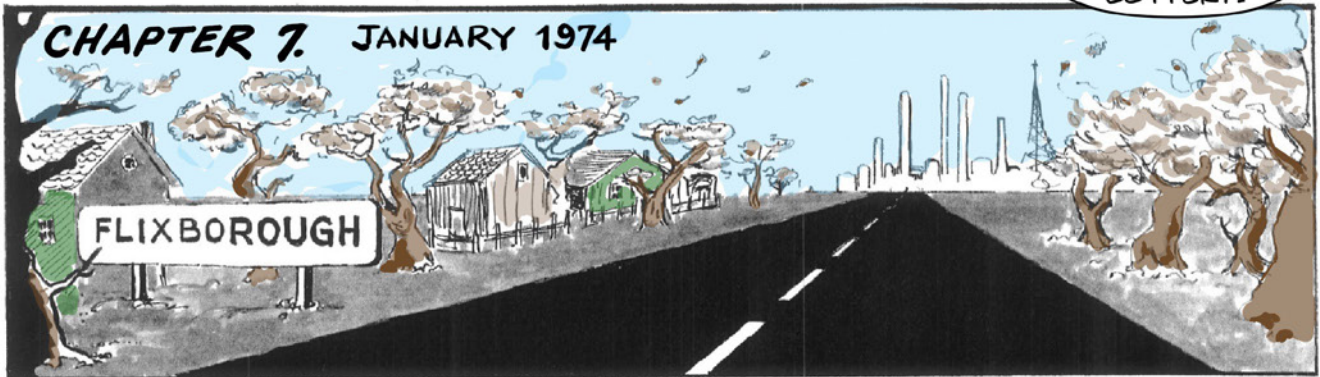
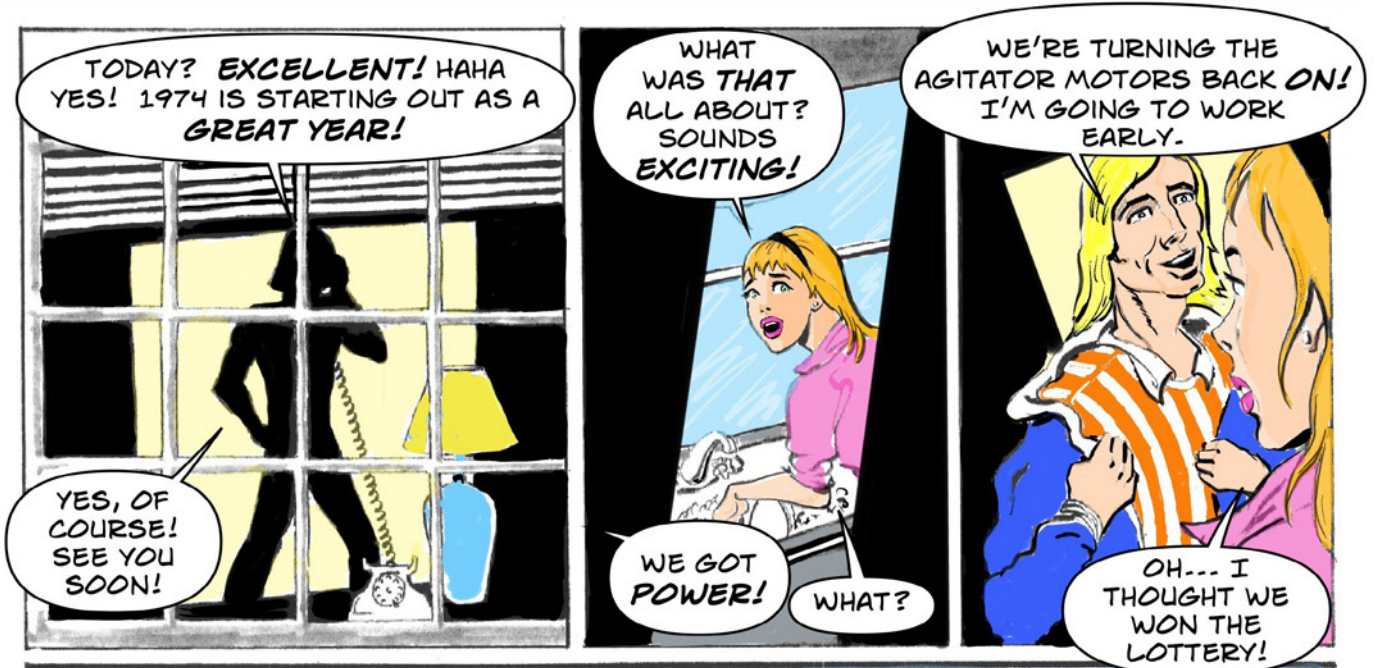


MAY I HAVE YOUR
CAR KEYS, SIR?

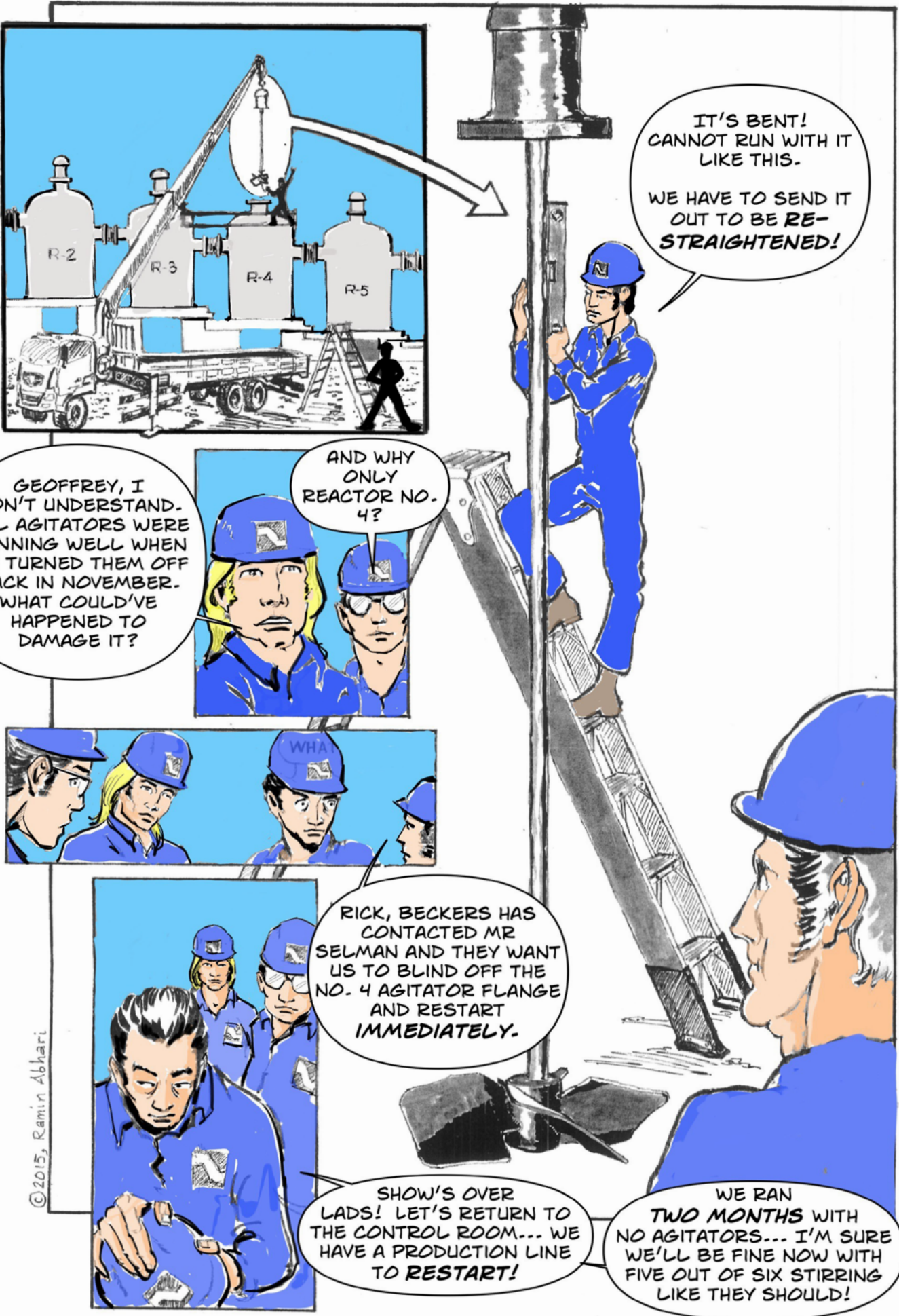


HERE
YOU GO,
MARY.

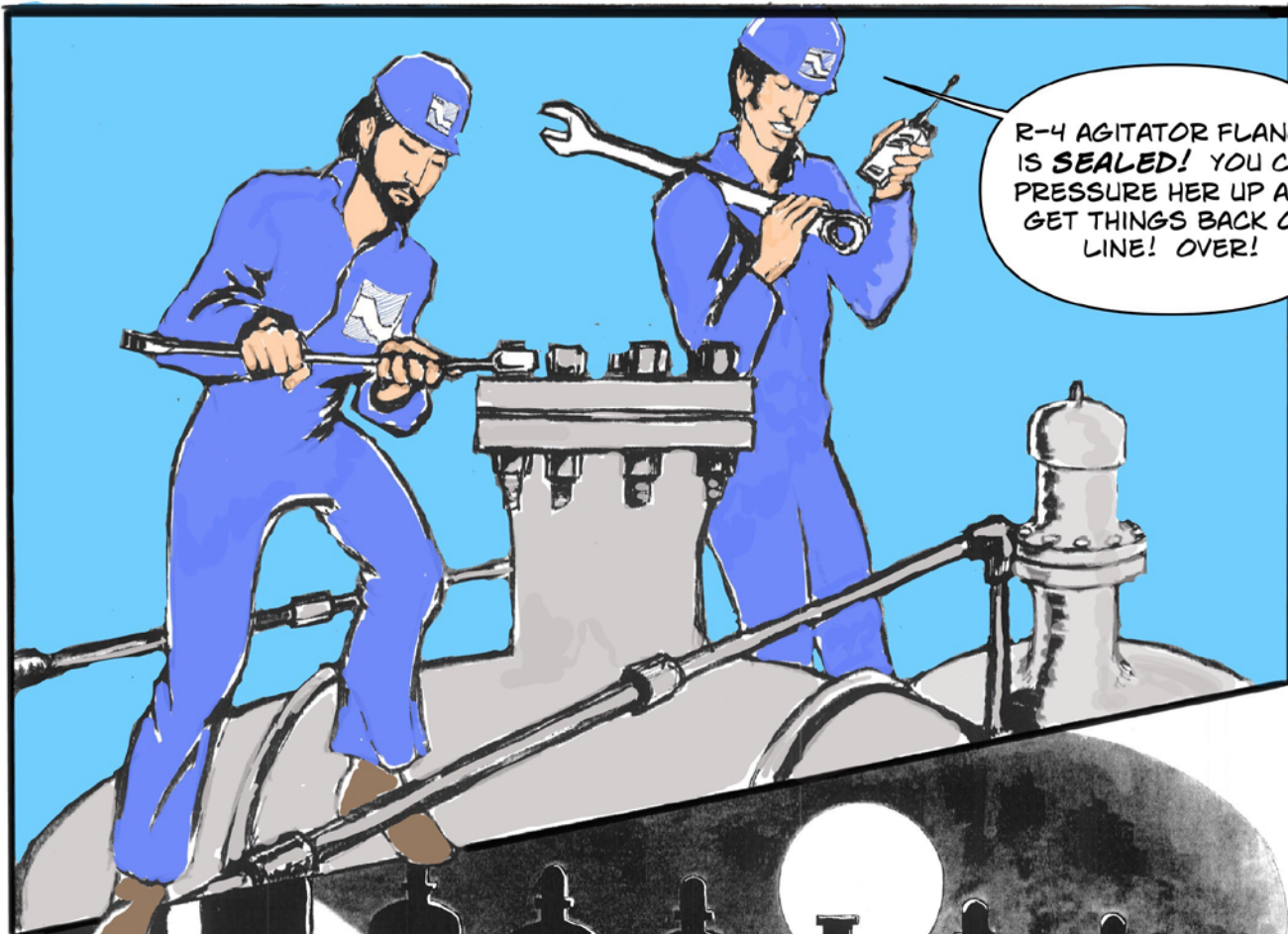
NEXT: THE BENT SHAFT!



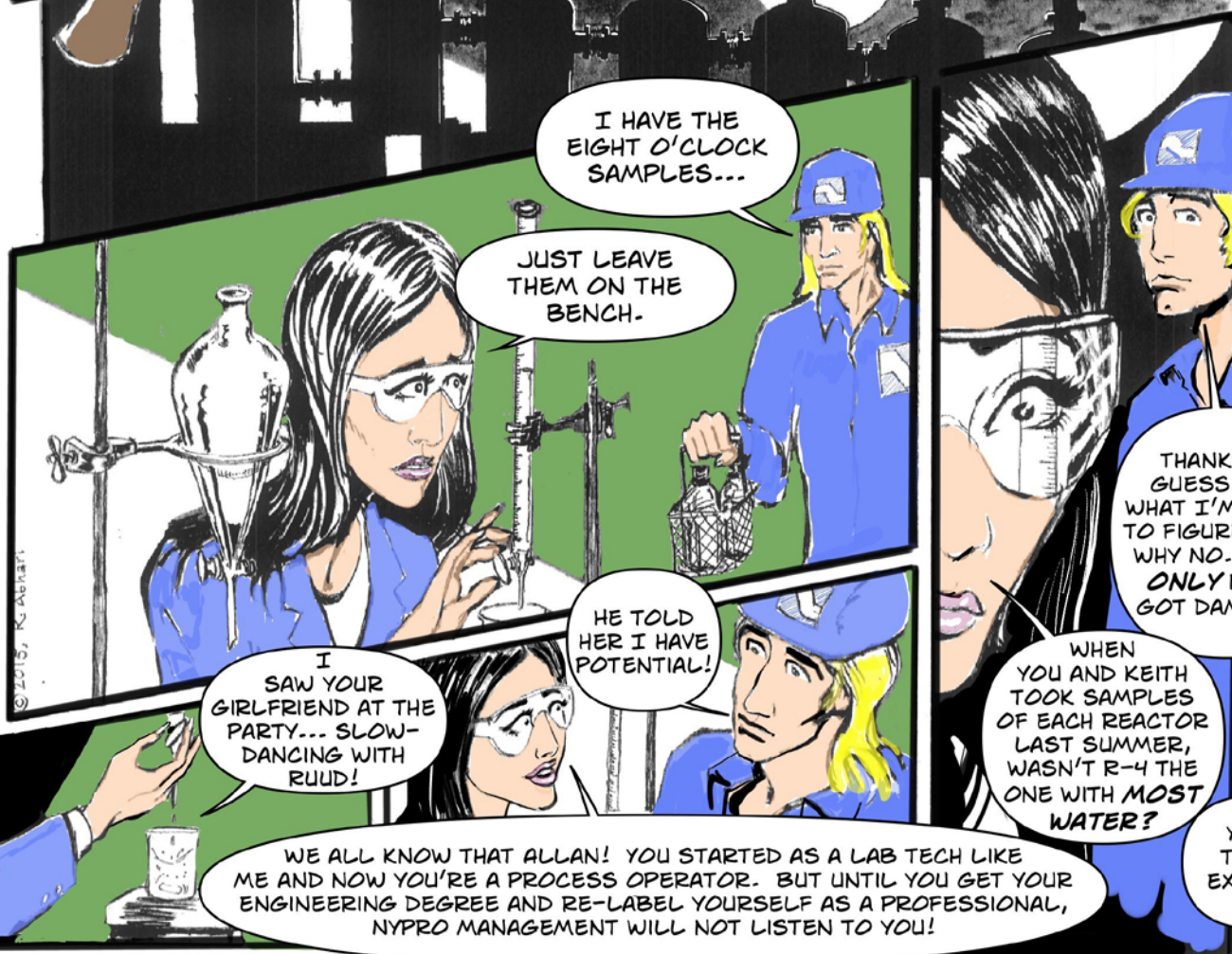
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R-4 AGITATOR FLANGE IS **SEALED!** YOU CAN PRESSURE HER UP AND GET THINGS BACK ON LINE! OVER!



I HAVE THE EIGHT O'CLOCK SAMPLES...

JUST LEAVE THEM ON THE BENCH.

I SAW YOUR GIRLFRIEND AT THE PARTY... SLOW-DANCING WITH RUUD!

HE TOLD HER I HAVE POTENTIAL!

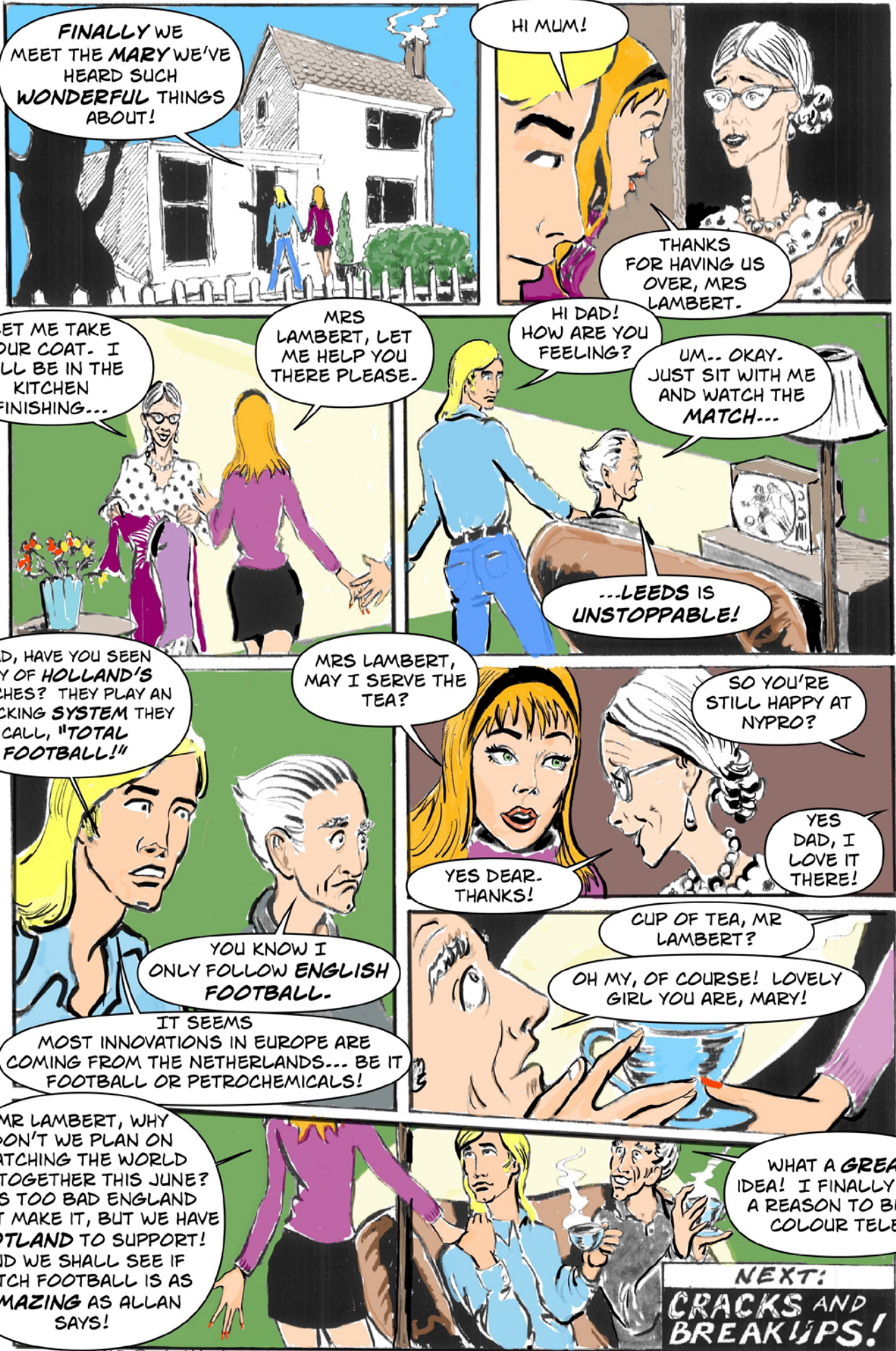
WE ALL KNOW THAT ALLAN! YOU STARTED AS A LAB TECH LIKE ME AND NOW YOU'RE A PROCESS OPERATOR. BUT UNTIL YOU GET YOUR ENGINEERING DEGREE AND RE-LABEL YOURSELF AS A PROFESSIONAL, NYPRO MANAGEMENT WILL NOT LISTEN TO YOU!



THANKS...I GUESS. BUT WHAT I'M TRYING TO FIGURE OUT IS WHY NO. 4- AND **ONLY** NO. 4- GOT DAMAGED.

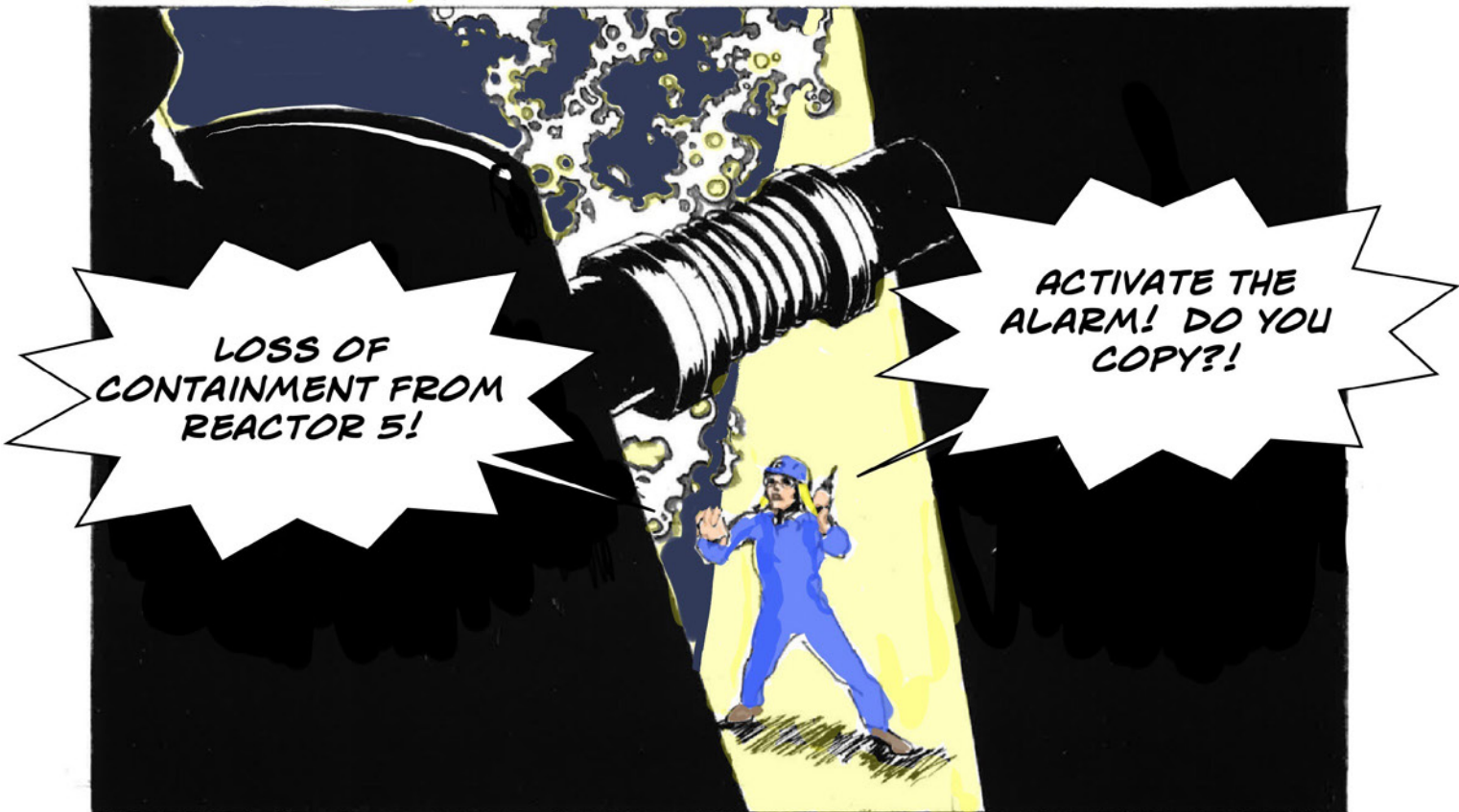
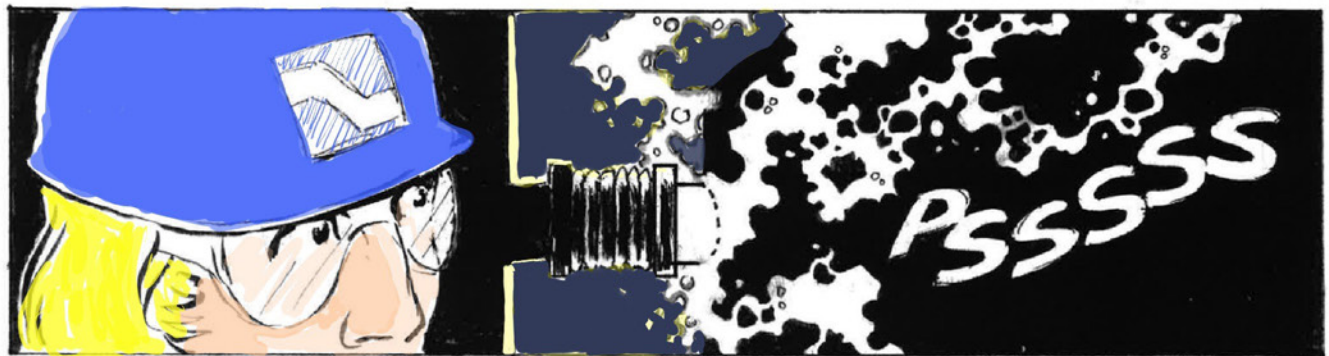
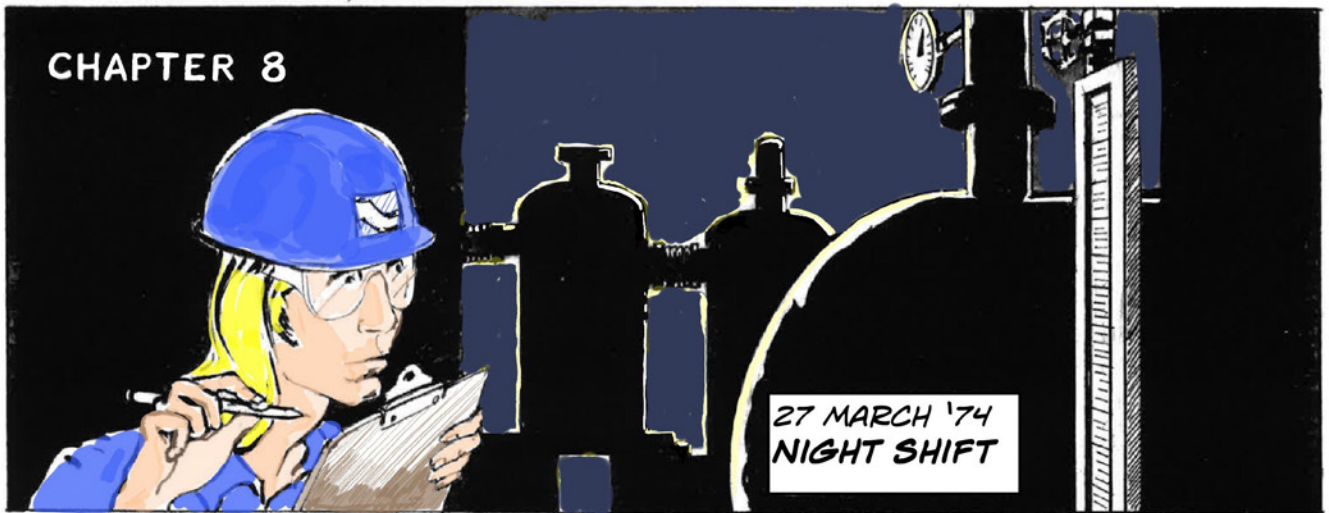
WHEN YOU AND KEITH TOOK SAMPLES OF EACH REACTOR LAST SUMMER, WASN'T R-4 THE ONE WITH **MOST** WATER?

YES... THAT... EXPLAINS IT.

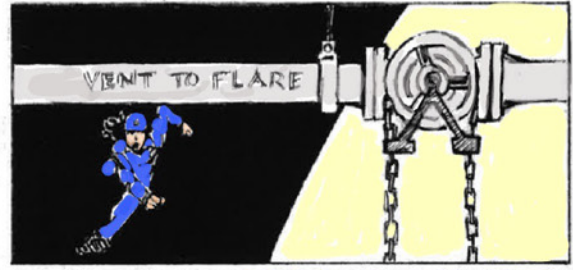
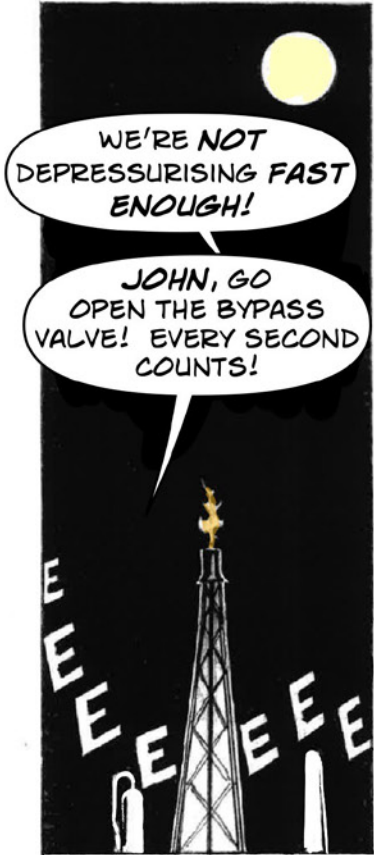
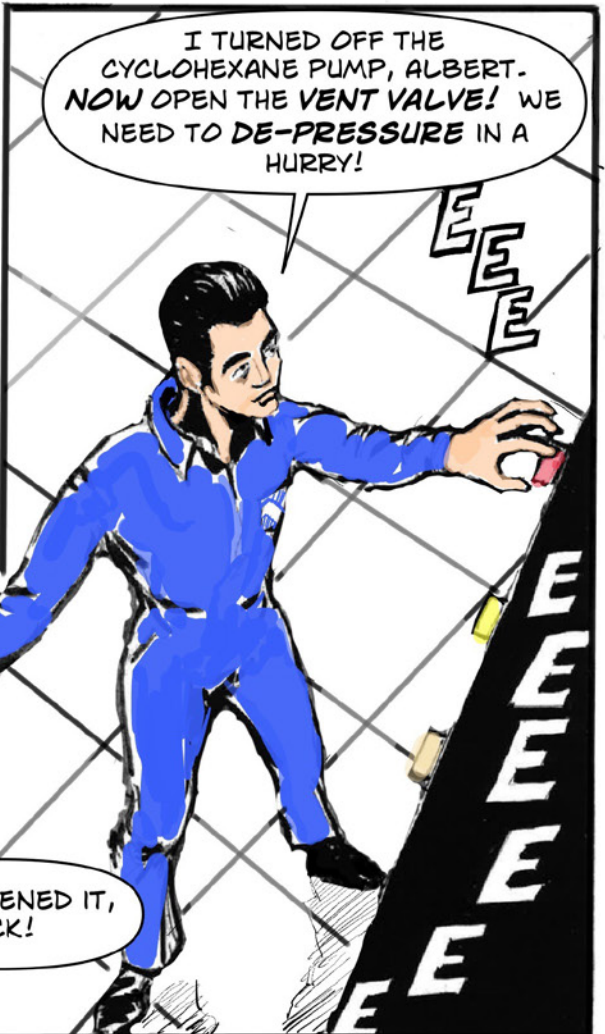
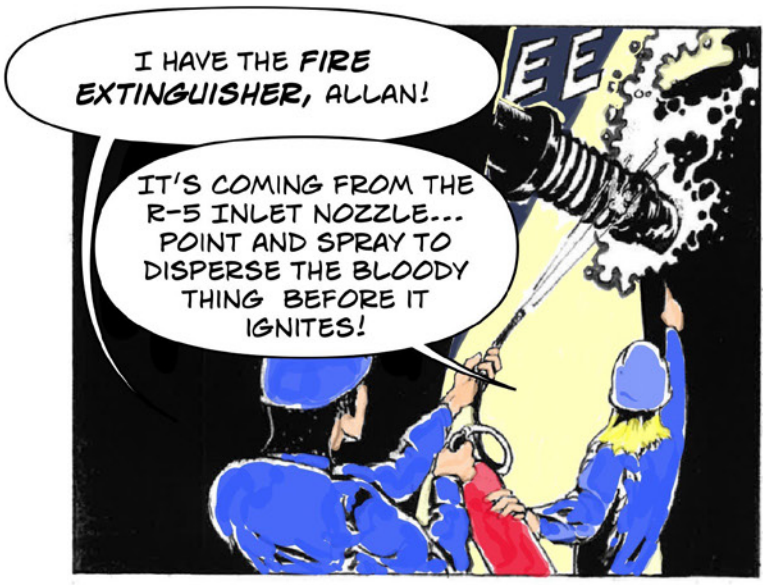


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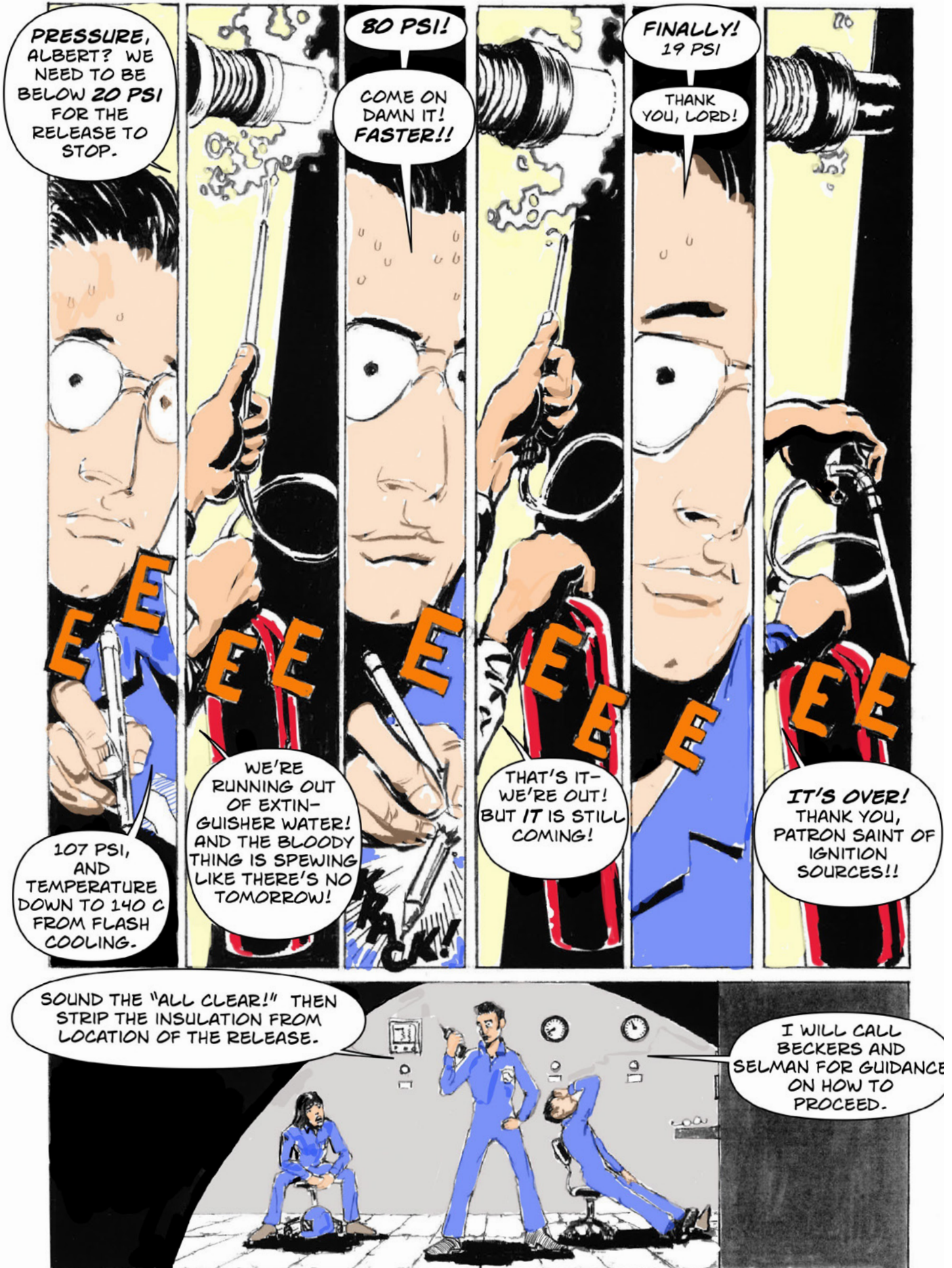
CHAPTER 8



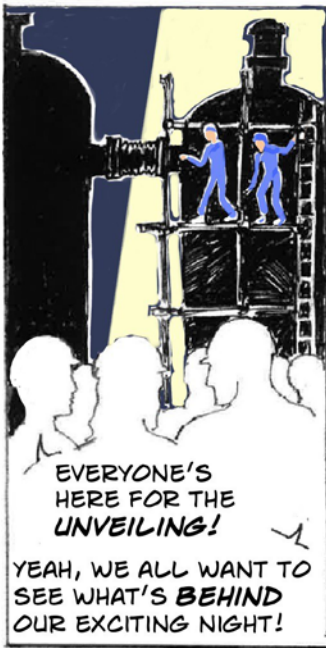
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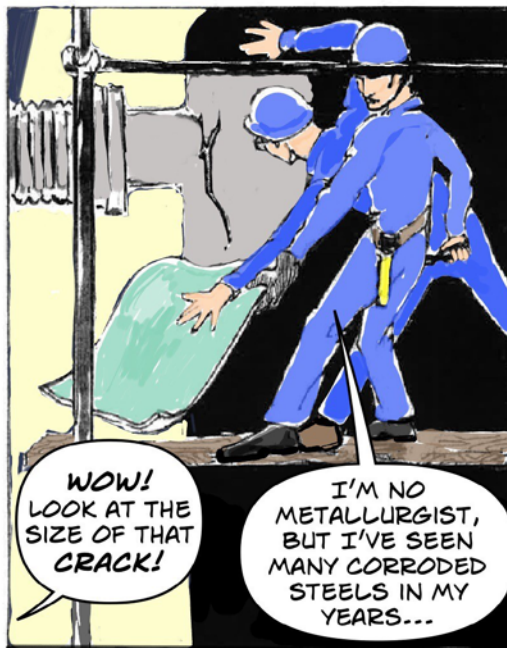
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EVERYONE'S HERE FOR THE UNVEILING!
YEAH, WE ALL WANT TO SEE WHAT'S BEHIND OUR EXCITING NIGHT!

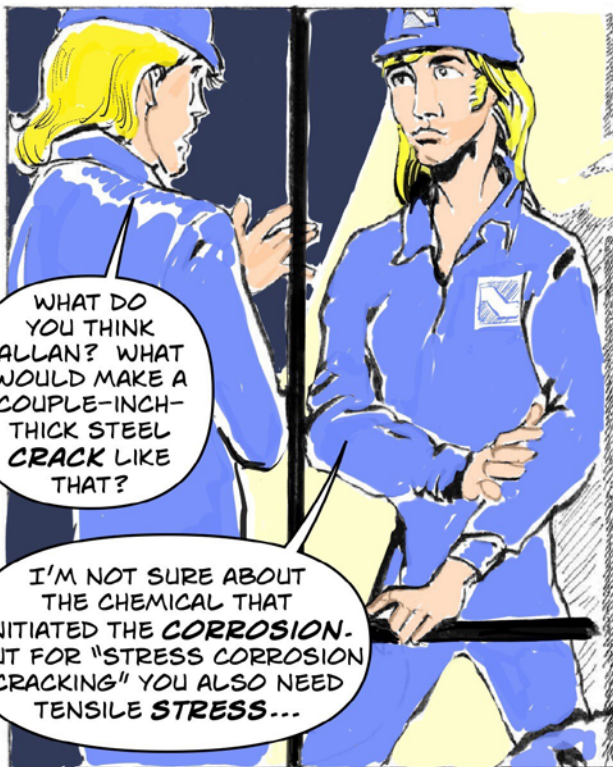


WOW! LOOK AT THE SIZE OF THAT CRACK!

I'M NO METALLURGIST, BUT I'VE SEEN MANY CORRODED STEELS IN MY YEARS...

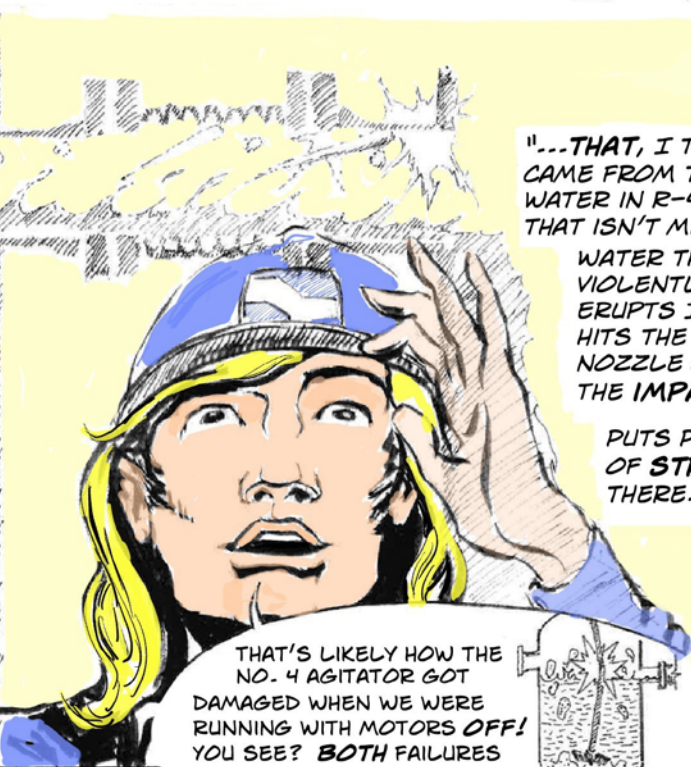


...THIS IS DEFINITELY STRESS CORROSION CRACKING!



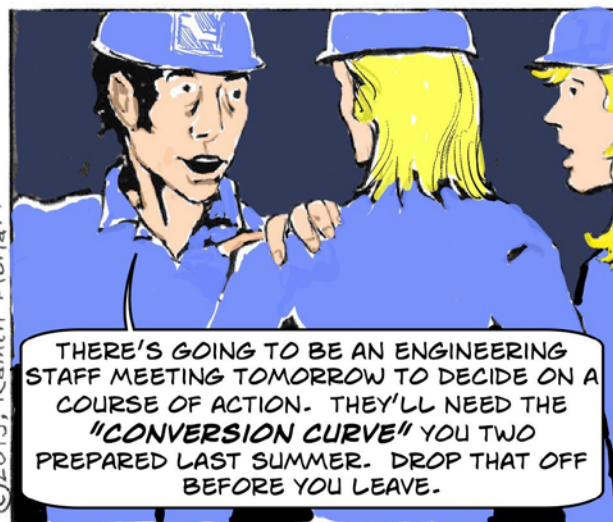
WHAT DO YOU THINK ALLAN? WHAT WOULD MAKE A COUPLE-INCH-THICK STEEL CRACK LIKE THAT?

I'M NOT SURE ABOUT THE CHEMICAL THAT INITIATED THE CORROSION. BUT FOR "STRESS CORROSION CRACKING" YOU ALSO NEED TENSILE STRESS...

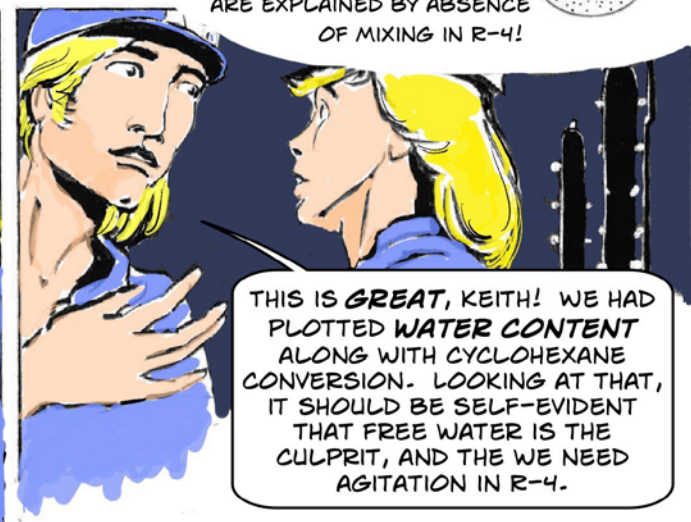


"...THAT, I THINK, CAME FROM THE WATER IN R-4 THAT ISN'T MIXED. WATER THAT VIOLENTLY ERUPTS IN NO.4 HITS THE INLET NOZZLE OF R-5! THE IMPACT PUTS PLENTY OF STRESS THERE."

THAT'S LIKELY HOW THE NO. 4 AGITATOR GOT DAMAGED WHEN WE WERE RUNNING WITH MOTORS OFF! YOU SEE? BOTH FAILURES ARE EXPLAINED BY ABSENCE OF MIXING IN R-4!

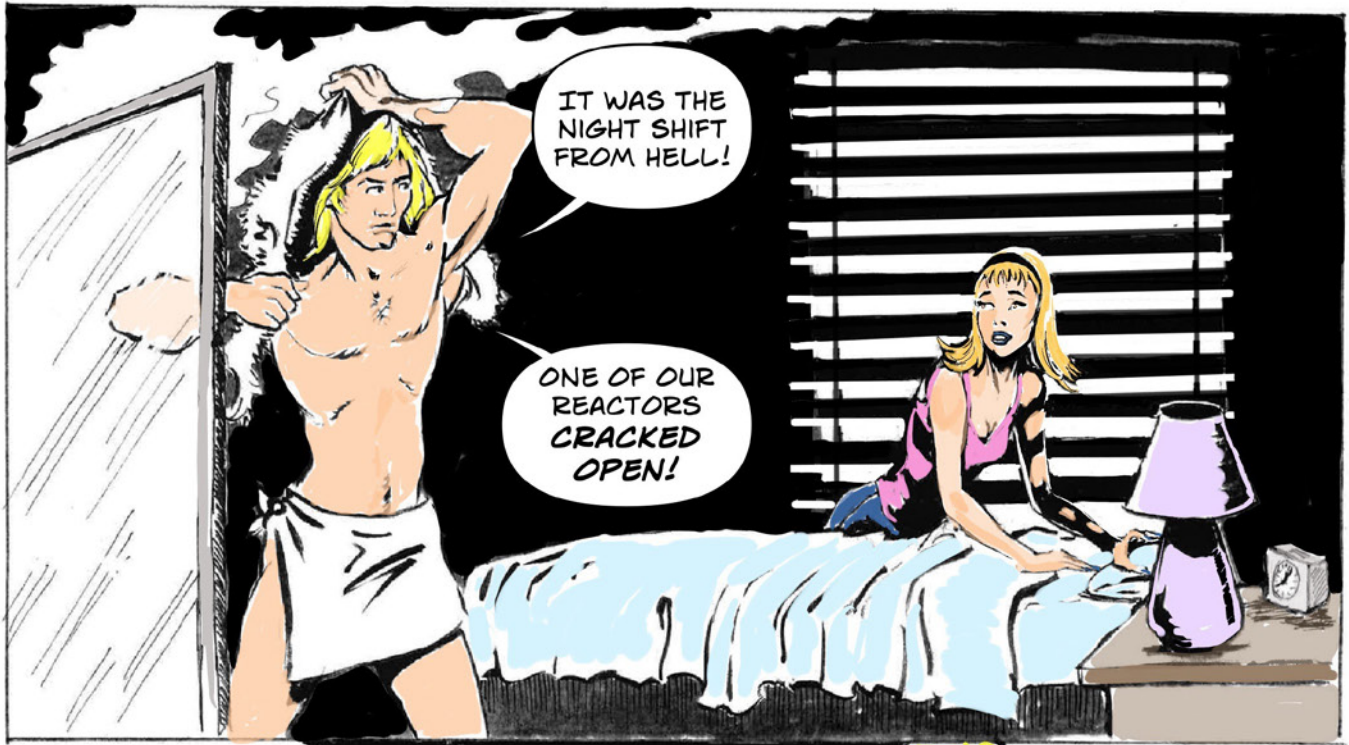


THERE'S GOING TO BE AN ENGINEERING STAFF MEETING TOMORROW TO DECIDE ON A COURSE OF ACTION. THEY'LL NEED THE "CONVERSION CURVE" YOU TWO PREPARED LAST SUMMER. DROP THAT OFF BEFORE YOU LEAVE.



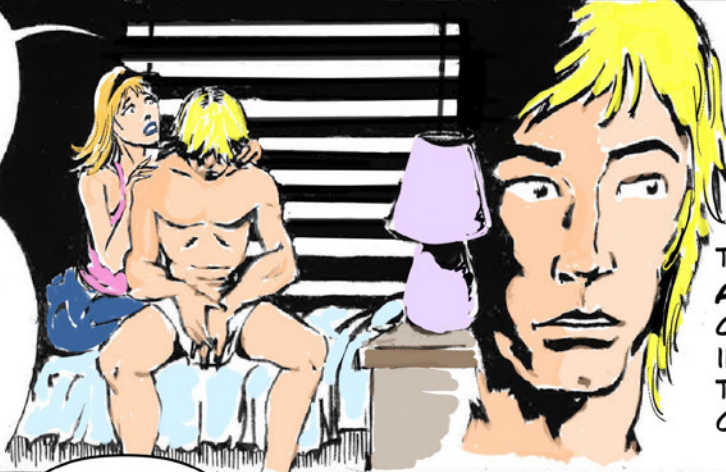
THIS IS GREAT, KEITH! WE HAD PLOTTED WATER CONTENT ALONG WITH CYCLOHEXANE CONVERSION. LOOKING AT THAT, IT SHOULD BE SELF-EVIDENT THAT FREE WATER IS THE CULPRIT, AND THE WE NEED AGITATION IN R-4.

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OH MARY, I WAS FACE-TO-FACE WITH THE MOST DESTRUCTIVE FORCE I'VE EVER SEEN.

A HYDROCARBON VAPOUR-AND-AEROSOL MIXTURE... EACH AEROSOL DROPLET CONTAINING POTENT OXIDATION CATALYST!



THE CATALYST IS AN ACCELERATOR FOR ALL OXIDATION REACTIONS... INCLUDING COMBUSTION! THE AEROSOL-VAPOUR CLOUD LINGERED ABOVE.



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28 MARCH

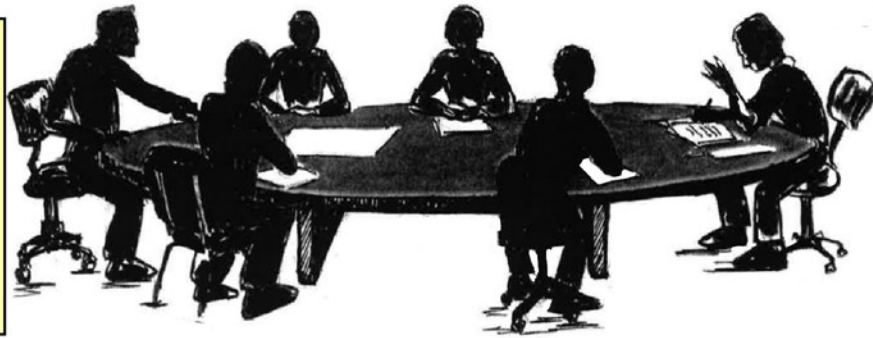
RICK, WHAT'S THE PLAN? ARE WE GOING TO WAIT UNTIL R-5 IS REPLACED AND WE HAVE AN AGITATOR IN R-4 BEFORE COMING BACKUP?

ALLAN, THAT WOULD TAKE MONTHS! RIUD CHALLENGED THE TECHNICAL STAFF TO COME UP WITH A WORK-AROUND THAT WOULD HAVE US UP AND RUNNING IN DAYS!

FIRST, WE CONFIRMED THAT NONE OF THE OTHER REACTORS SHOW ANY SIGN OF STRESS CORROSION CRACKING.



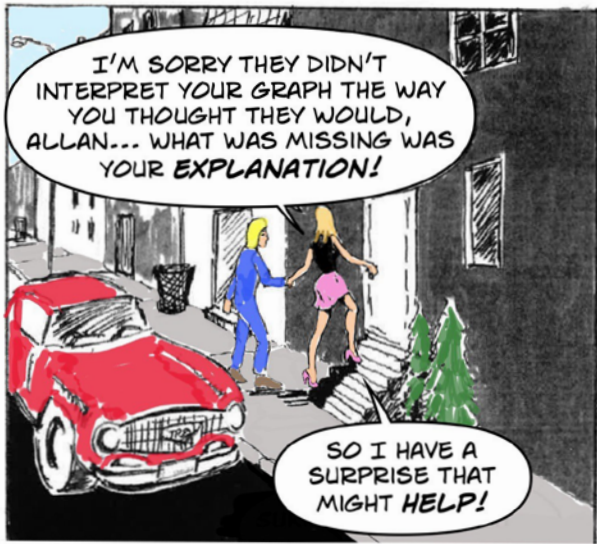
"THEN THE ENGINEERS LOOKED AT THE CONVERSION DATA AND CONFIRMED THAT VIRTUALLY ALL THE OXIDATION HAPPENS IN THE FIRST FIVE REACTORS. ALL WE NEED TO RUN IS FIVE WORKING REACTORS!"



"THEY CAME UP WITH A PIPE DESIGN FOR FLOWING DIRECTLY FROM HIGHER R-4 TO LOWER R-6. THE CRACKED R-5 IS BEING REMOVED FOR METALLURGICAL TESTS AND REPLACEMENT."



"THEY DREW UP THE PROPOSED PIPE ON THE SHOP FLOOR AND THE LADS THERE HAVE ALREADY STARTED FABRICATION!"



I'M SORRY THEY DIDN'T INTERPRET YOUR GRAPH THE WAY YOU THOUGHT THEY WOULD, ALLAN... WHAT WAS MISSING WAS YOUR EXPLANATION!

SO I HAVE A SURPRISE THAT MIGHT HELP!



A TYPEWRITER MARY?!

IT COMES WITH A SEXY SECRETARY WHO'LL HELP YOU WRITE A PROFESSIONAL MEMO!

IN IT, YOU CAN EXPLAIN YOUR CONCERN ABOUT RUSHING TO RESTART WITHOUT THAT MIXER.



SNAP!

CONCERNS ABOUT MODIFICATIONS TO REACTOR SYSTEM

HERE WE GO. FROM ALLAN LAMBERT, TO RUUD SELMAN. DATE, 28 MARCH 1974. SUBJECT?

I LIKE IT! NOW EXPLAIN THE WHOLE THING LIKE YOU DID TO ME.



I UNDERSTAND THE PRESSURE TO RESTART QUICKLY TO MEET OUR COMMERCIAL TARGETS. HOWEVER, SINCE WE DO NOT YET UNDERSTAND THE ROOT CAUSE OF THE 27 MARCH FAILURE OF R-5, WE RISK A REPEAT.



TAP! TAP! TAP!
TAP! TAP! TAP!
TAP! TAP!



GULP! GULP!
GULP! GULP!

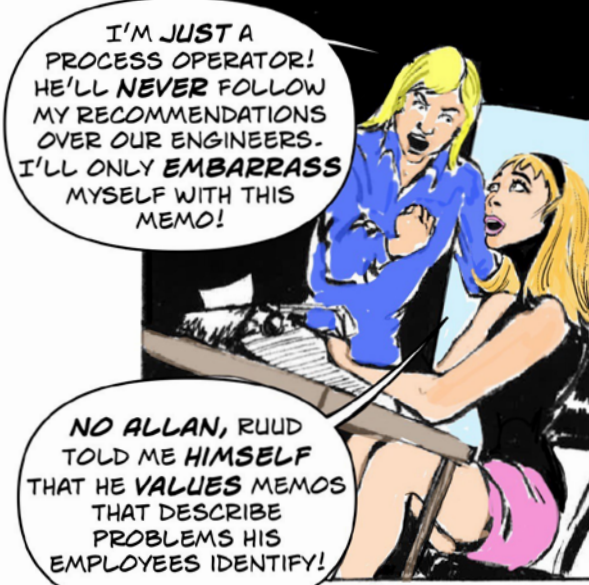
I BELIEVE THE ROOT CAUSE INVOLVES WATER LAYER IN UNAGITATED R-4. I THUS URGE A DELAY UNTIL A WORKING AGITATOR IS INSTALLED. WHILE WAITING FOR THE AGITATOR, WE CAN HAVE MECHANICAL REVIEW OF THE PROPOSED R4-TO-R6 PIPE.



TAP! TAP!
TAP! TAP!
TAP! TAP!



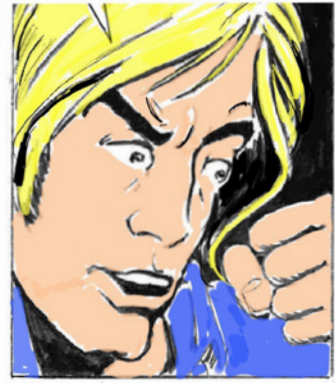
THIS IS STUPID!
STUPID!



I'M JUST A PROCESS OPERATOR! HE'LL NEVER FOLLOW MY RECOMMENDATIONS OVER OUR ENGINEERS. I'LL ONLY EMBARRASS MYSELF WITH THIS MEMO!

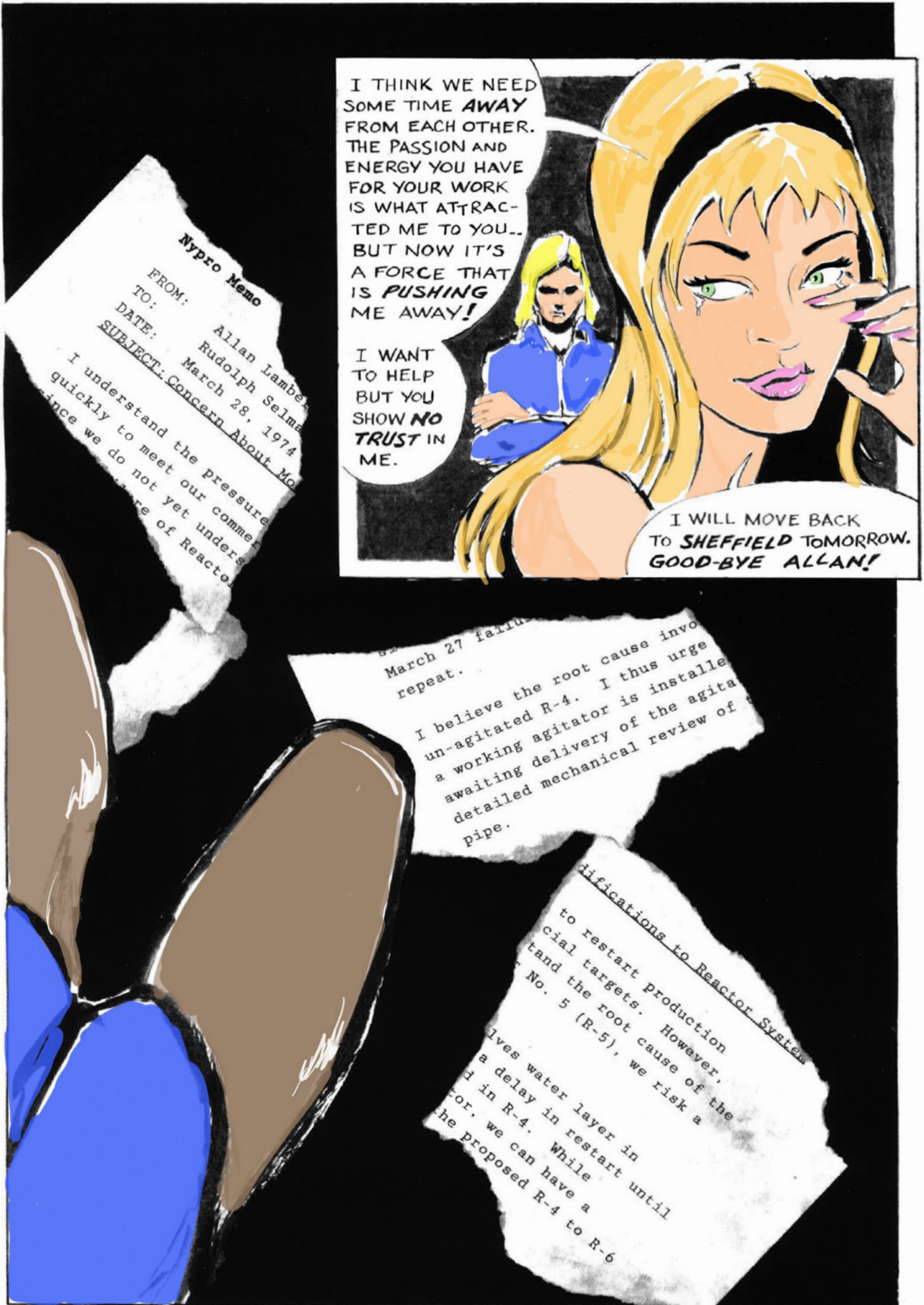
NO ALLAN, RUUD TOLD ME HIMSELF THAT HE VALUES MEMOS THAT DESCRIBE PROBLEMS HIS EMPLOYEES IDENTIFY!

HA! HA! WHAT HAPPENED TO CORPORATE BULLSHIT MARY?! ONE DANCE WITH THE BOSS AND YOU'RE A BELIEVER IN ENLIGHTENED MANAGEMENT?!



RIP!

FINE! FORGET THE WHOLE THING!



I THINK WE NEED SOME TIME **AWAY** FROM EACH OTHER. THE PASSION AND ENERGY YOU HAVE FOR YOUR WORK IS WHAT ATTRACTED ME TO YOU.. BUT NOW IT'S A FORCE THAT IS **PUSHING** ME AWAY!

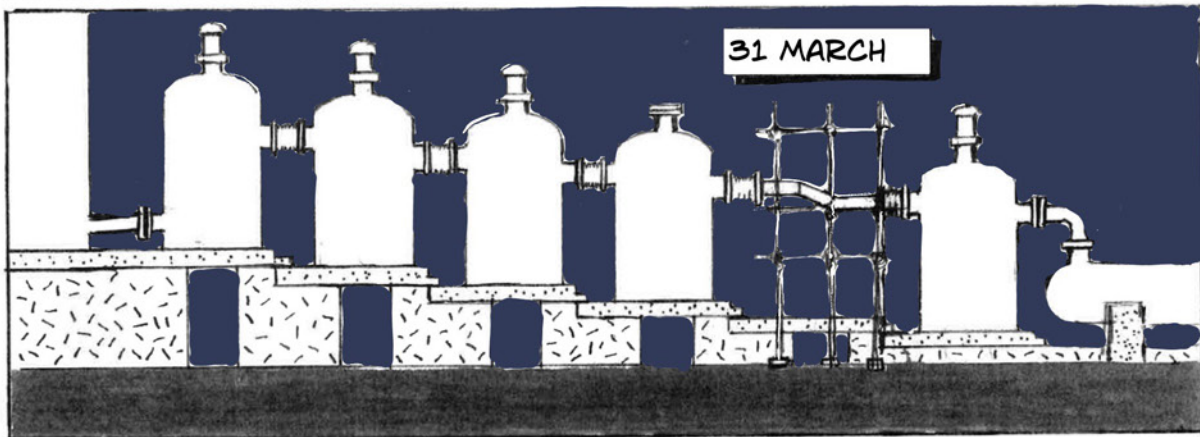
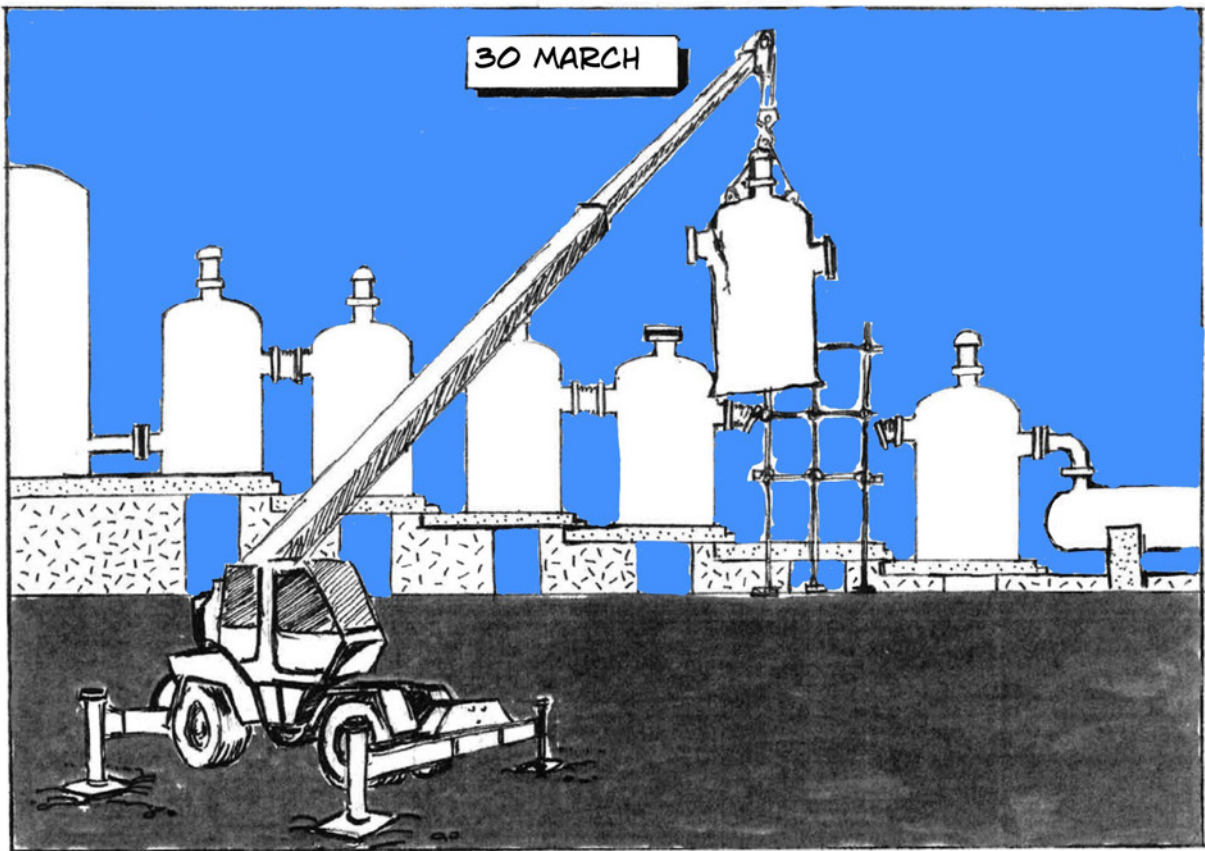
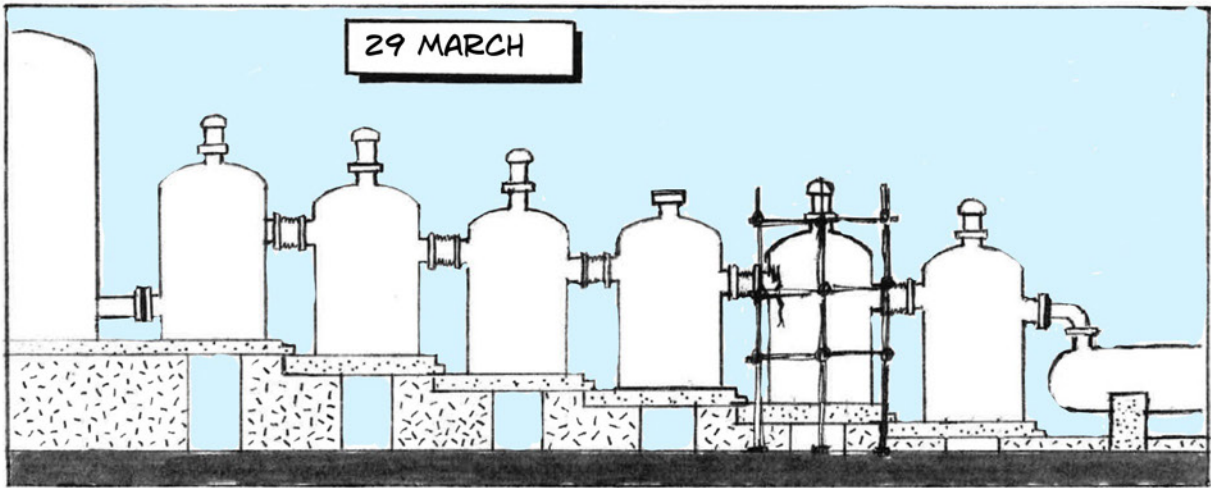
I WANT TO HELP BUT YOU SHOW **NO TRUST** IN ME.

I WILL MOVE BACK TO **SHEFFIELD** TOMORROW. **GOOD-BYE ALLAN!**

Nypro Memo
 FROM: Allan Lambert
 TO: Rudolph Selma
 DATE: March 28, 1974
 SUBJECT: Concern About Mo
 I understand the pressure quickly to meet our comm since we do not yet unders
 ure of Reactor

March 27 failu
 repeat.
 I believe the root cause invo un-agitated R-4. I thus urge a working agitator is install awaiting delivery of the agita detailed mechanical review of pipe.

ifications to Reactor System
 to restart production cial targets. However, stand the root cause of the No. 5 (R-5), we risk a lves water layer in a delay in restart until d in R-4. While or, we can have a he proposed R-4 to R-6



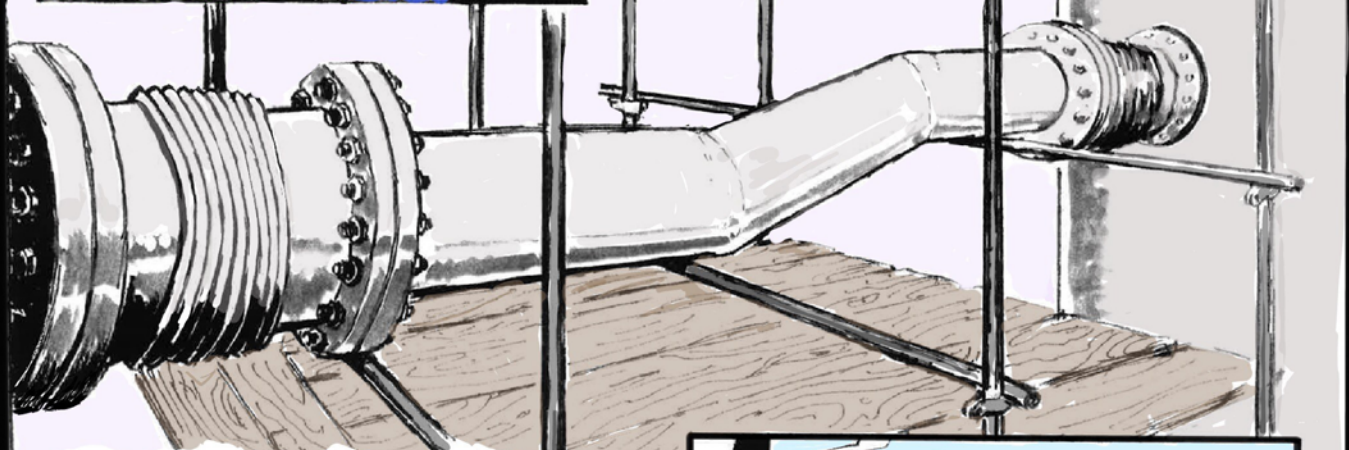
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**NEXT:
LAST POSTCARD FROM FLIXBOROUGH**

CHAPTER NINE

Flixborough, 7 April 1974

Dear Mary,
 I'm sorry I lost my temper. I just felt so powerless at that moment. Things around me were changing and I had no say in the matter. Your faith in my ability to influence the events with my words just added to the pressure-- and perhaps brought out my working class insecurities. I became angry and said hurtful things. Sorry.
 Well, we've been up and running, making the product that keeps our customers' nylon lines spinning. Everyone's happy!

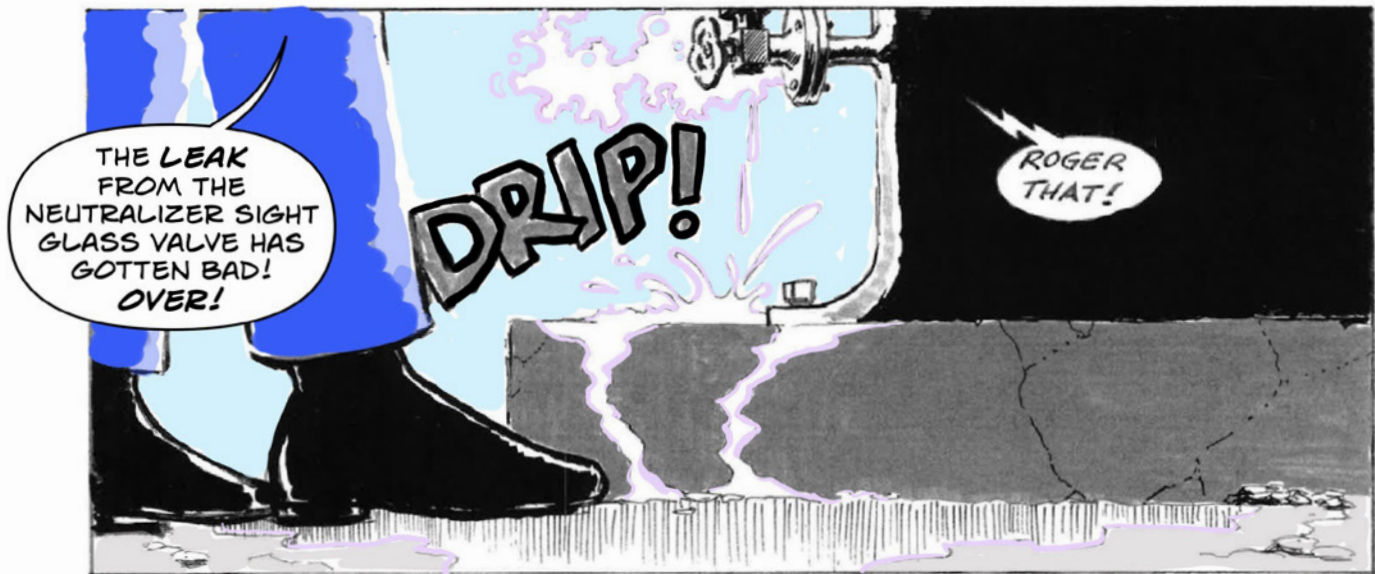
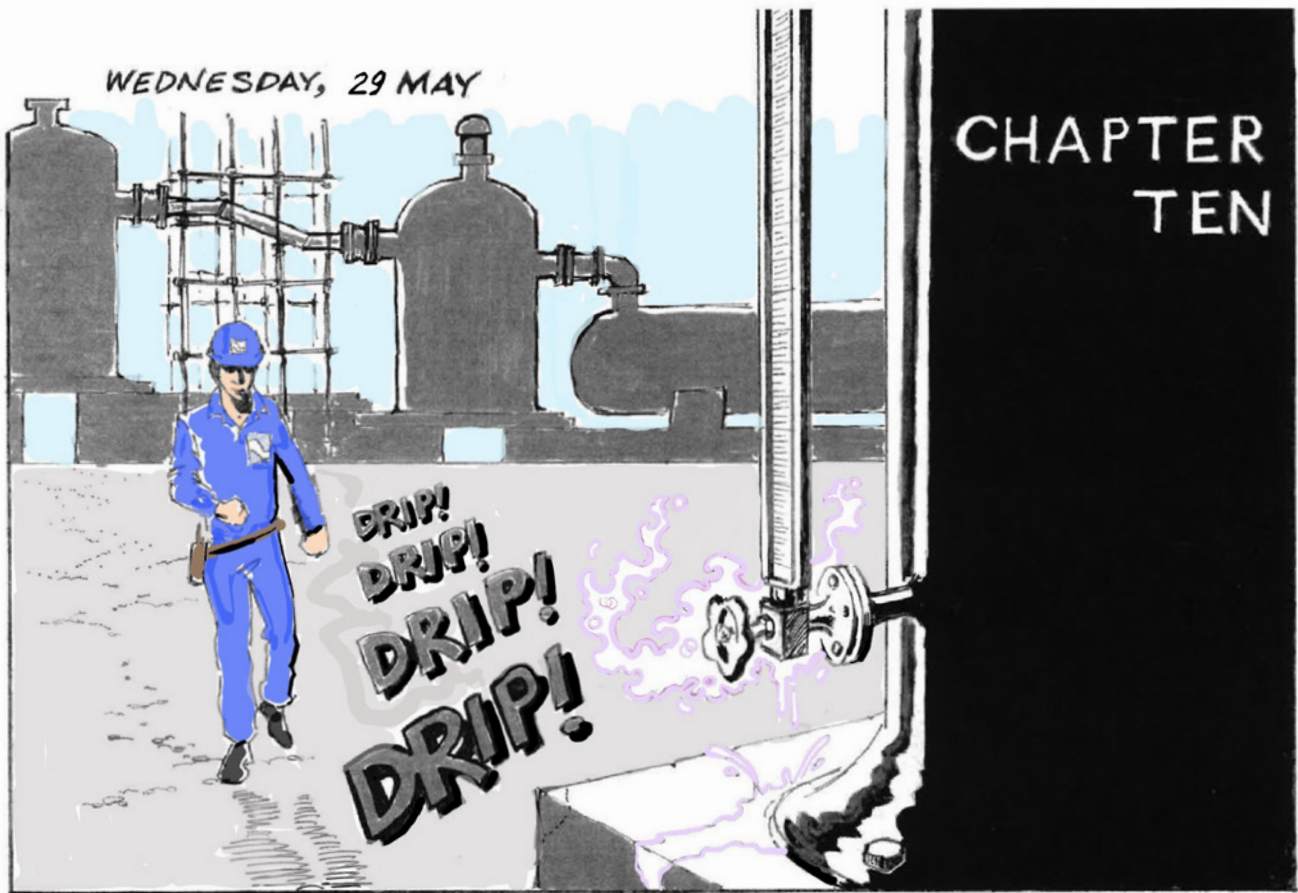


Maybe I was unnecessarily concerned. I don't know. The temporary pipe supported by scaffolds is now an integral part of the process. R-4 still has no agitator. And it all seems normal now. You see? Our perception has changed.

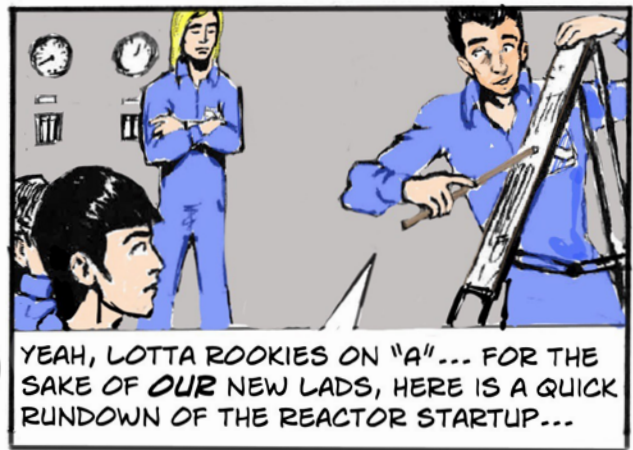
Love, Allan



NEXT UNCONFINED DESTRUCTION!

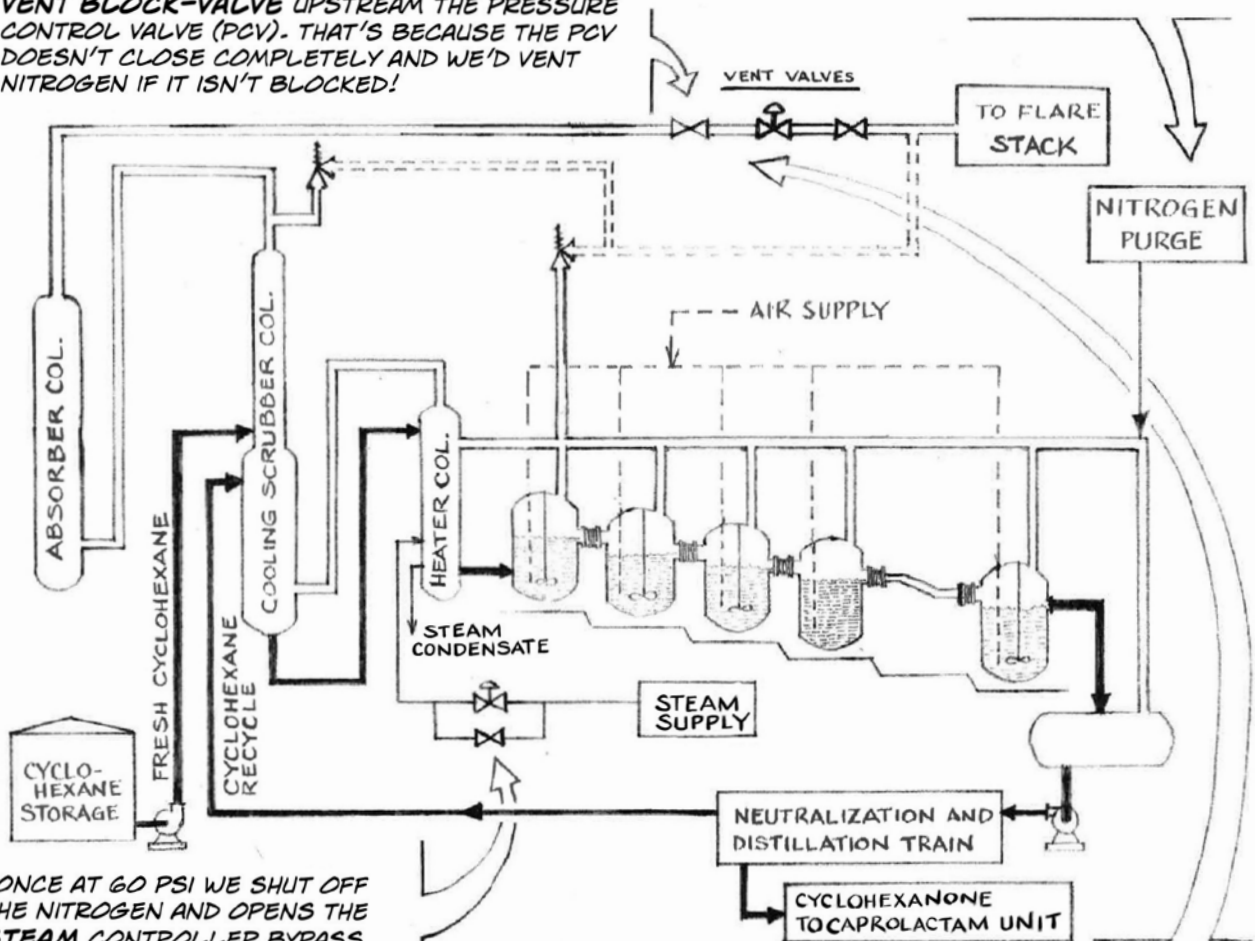


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"TO DO THAT, WE HAVE TO **CLOSE** THE MANUAL VENT BLOCK-VALVE UPSTREAM THE PRESSURE CONTROL VALVE (PCV). THAT'S BECAUSE THE PCV DOESN'T CLOSE COMPLETELY AND WE'D VENT NITROGEN IF IT ISN'T BLOCKED!

"FIRST THING AFTER CYCLOHEXANE CIRCULATION, WE PRESSURIZE THE REACTOR SYSTEM TO 60 PSI WITH NITROGEN...



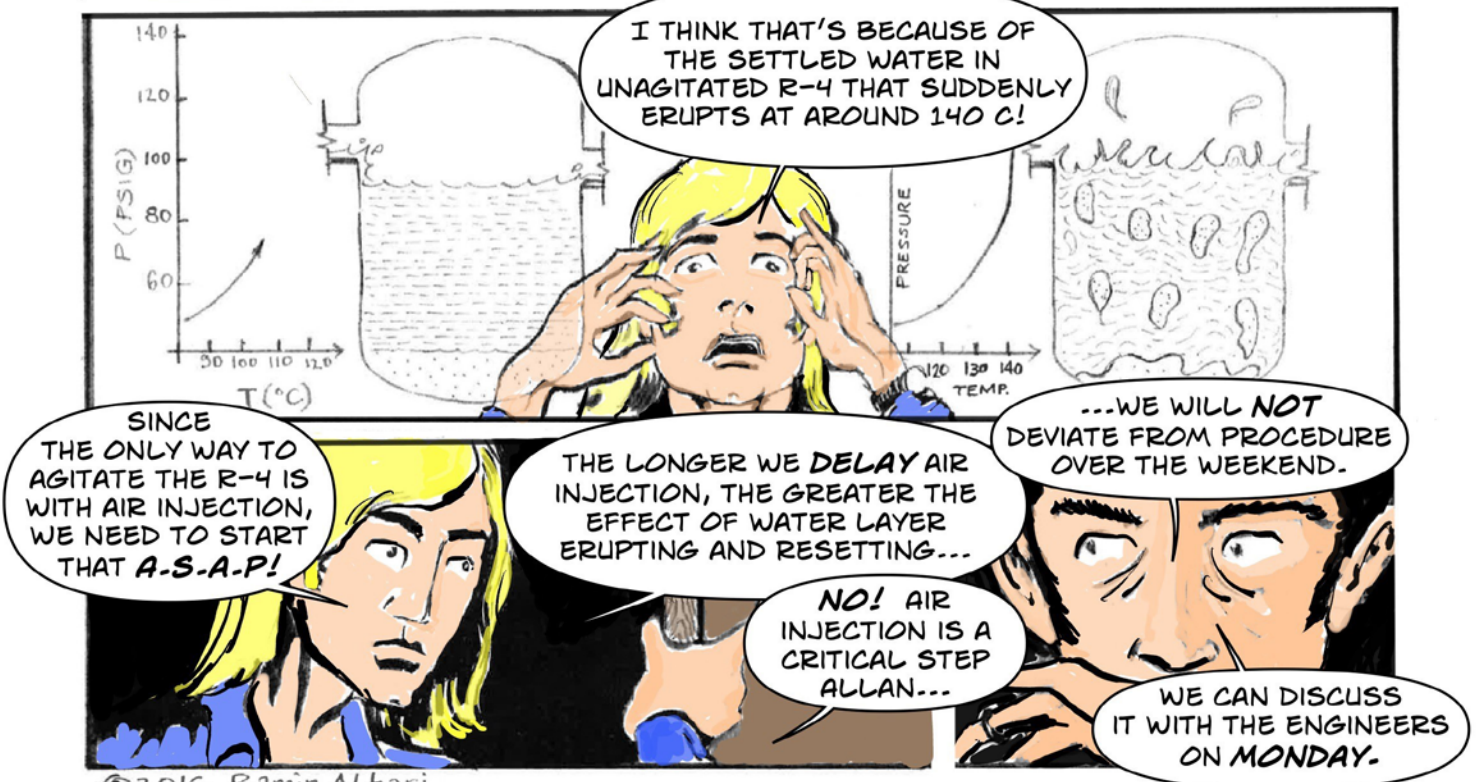
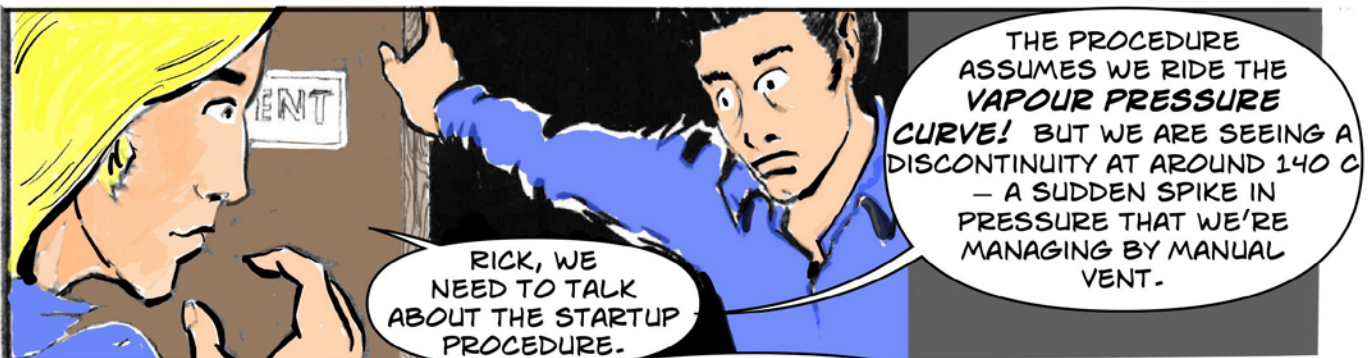
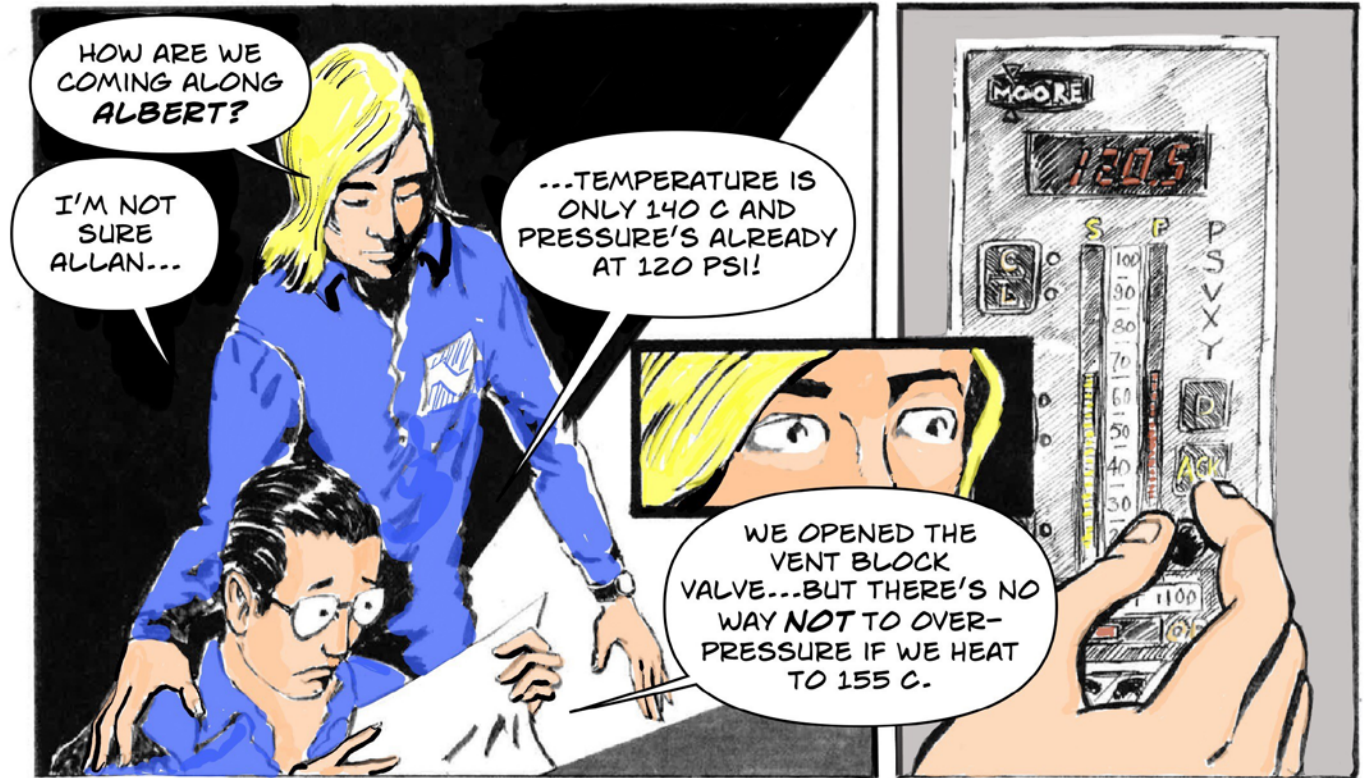
"ONCE AT 60 PSI WE SHUT OFF THE NITROGEN AND OPENS THE **STEAM** CONTROLLER BYPASS VALVE TO HEAT UP THE REACTORS.

"CYCLOHEXANE VAPOUR PRESSURE INCREASES WITH TEMPERATURE. WHEN PRESSURE REACHES 120 PSI, OPEN THE PCV BLOCK-VALVE FOR AUTO-CONTROL WITH 125 PSI SET-POINT.

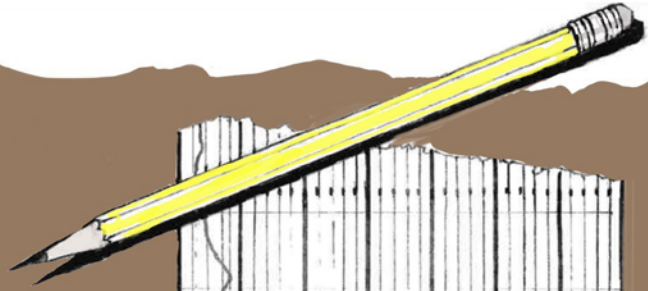
"THE TEMPERATURE CONTROL MAY BE PUT IN AUTO AT 155 C SET-POINT BY CLOSING THE BYPASS VALVE. DO THAT ANYTIME AFTER REACTORS REACH 140 C."



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FRIDAY 31 MAY,
11 P.M.- SHIFT



BLOODY HELL!
PRESSURE JUST
SHOT UP AGAIN...
GOTTA VENT.

SATURDAY 1 JUNE, 3 A.M SHIFT



I THINK
I'M HOLDING
PRESSURE OF 125 PSI.
AT 150 C- BUT ONLY
WITH VENT VALVE 20%
OPEN AND NITROGEN
SUPPLY ON.

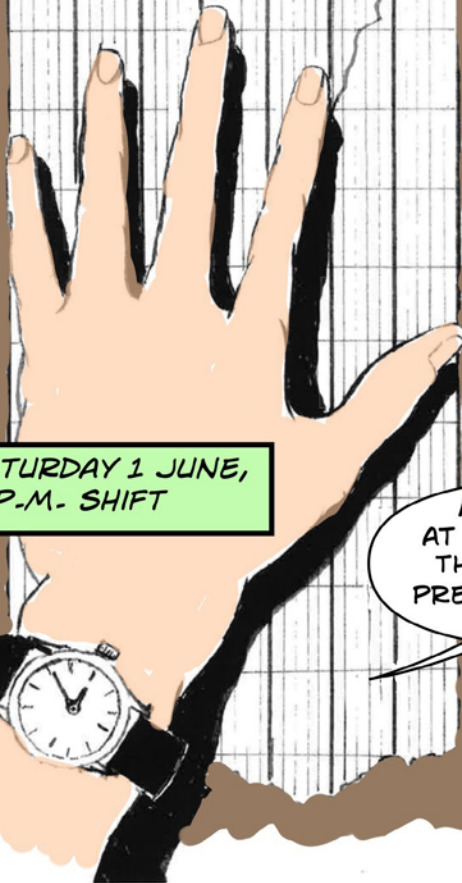
YOU'RE
WASTING
NITROGEN MAN!

SATURDAY 1 JUNE,
11 A.M SHIFT



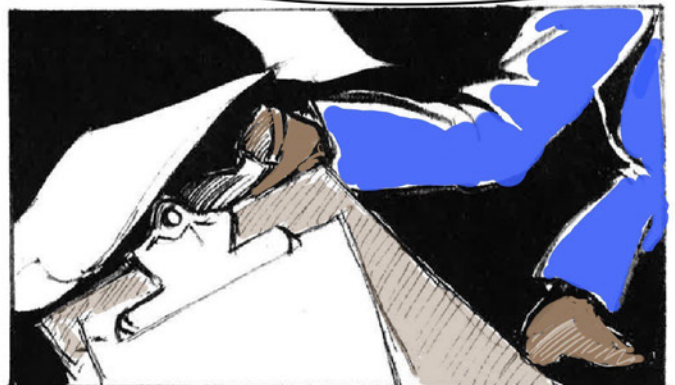
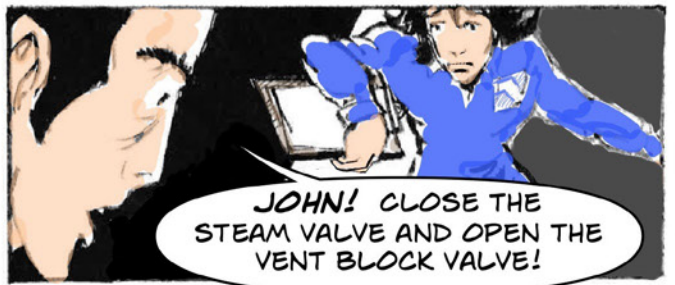
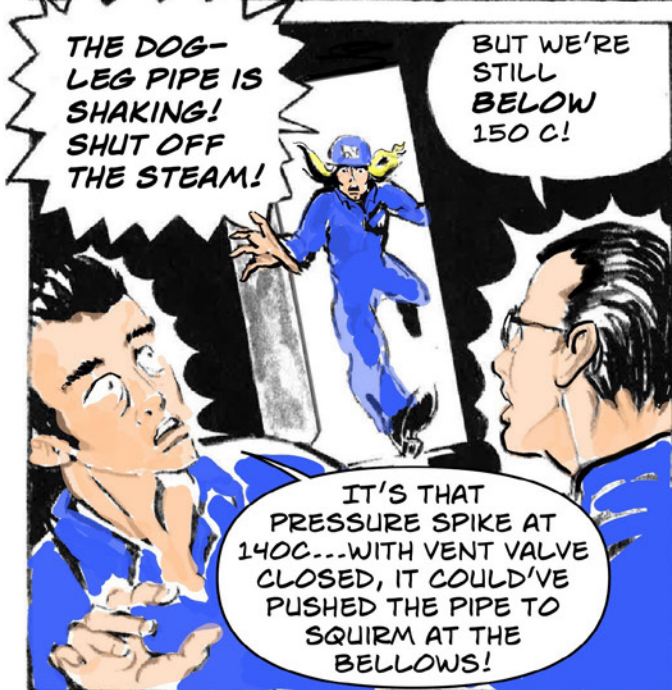
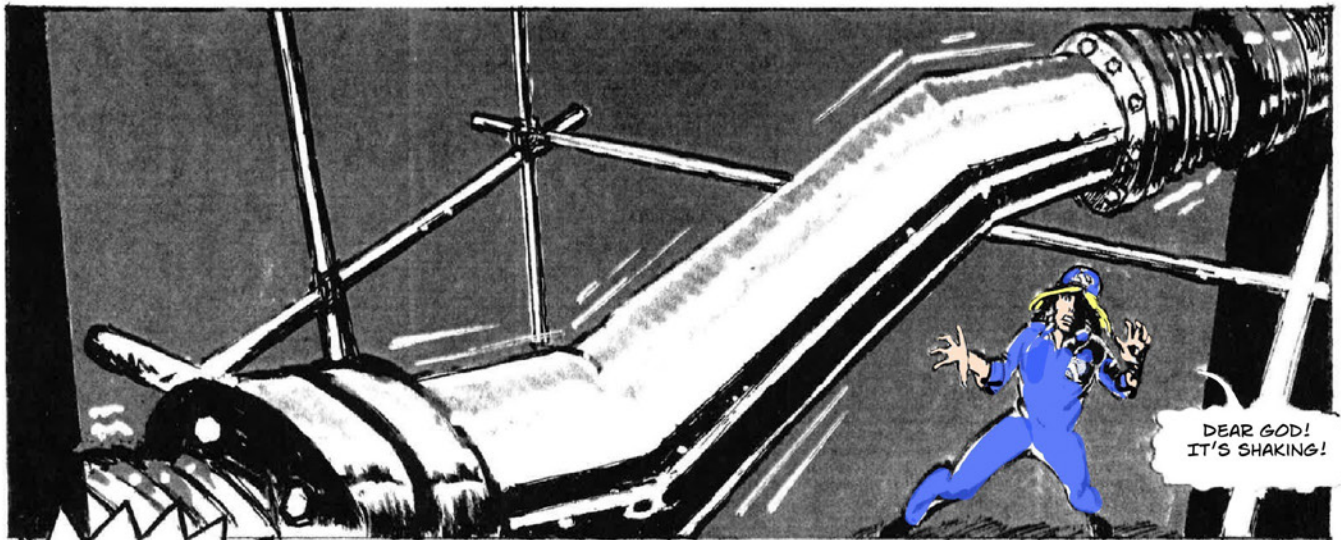
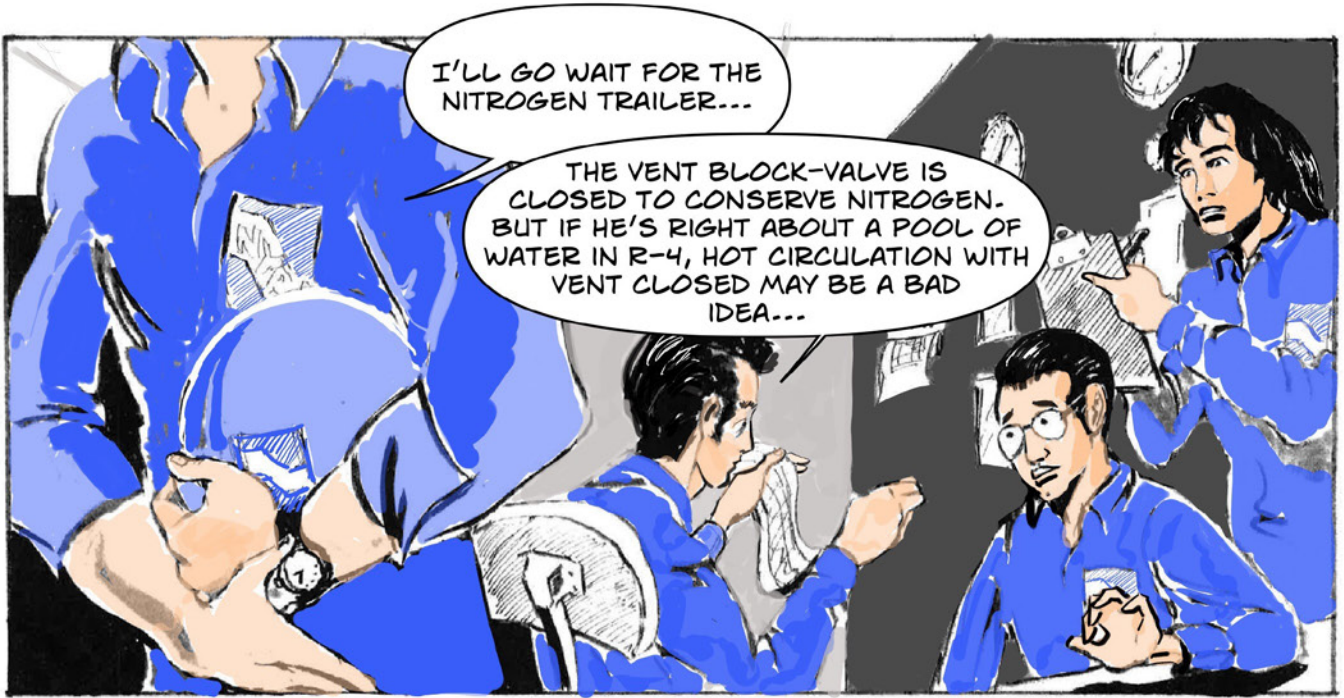
YES,
I'M CALLING FROM
NYPRO TO REQUEST A
NITROGEN DELIVERY...
TODAY!

SATURDAY 1 JUNE,
3 P.M.- SHIFT

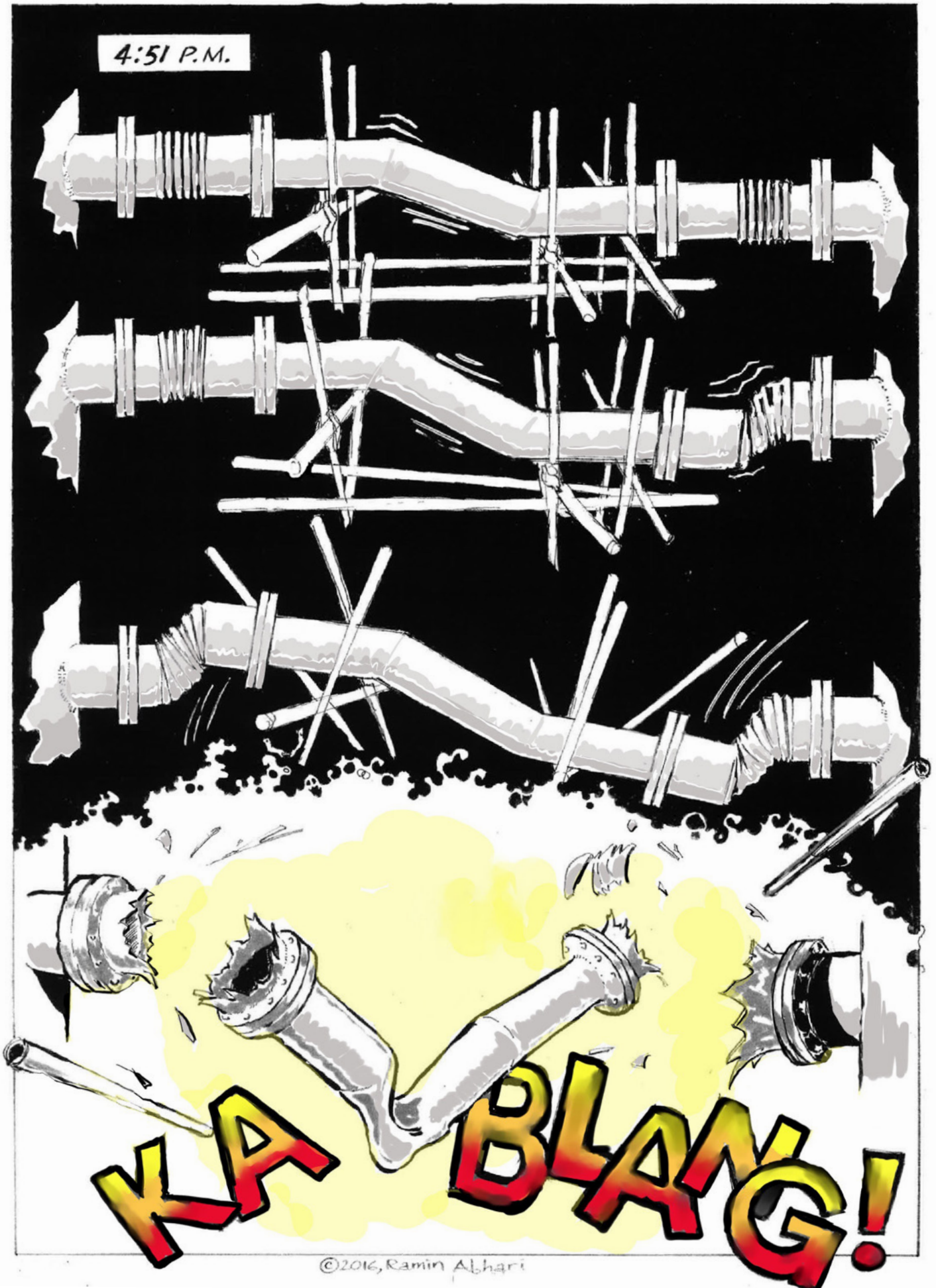


**RICK, TAKE A LOOK
AT THESE STRIP CHARTS!
THEY STRUGGLED WITH
PRESSURE CONTROL ALL
DAY!**

ALLAN, WE'LL KEEP IT IN HOT
CIRCULATION WITH THE VENT VALVE
CLOSED UNTIL NITROGEN DELIVERY.

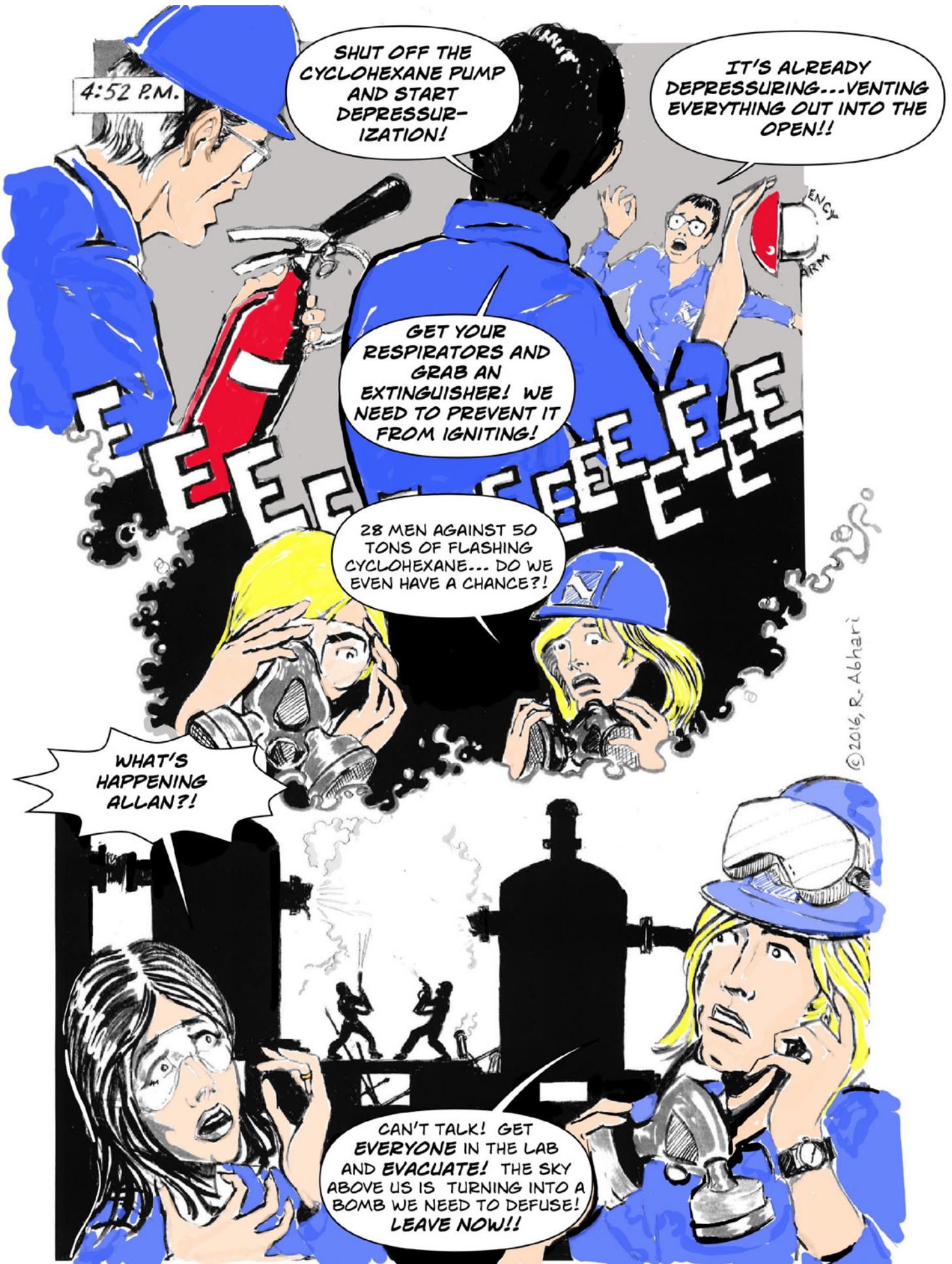


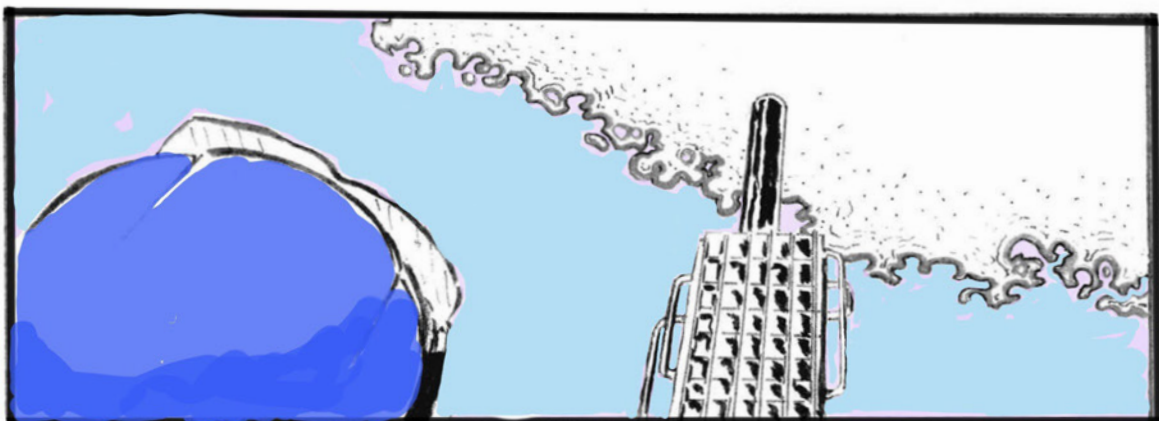
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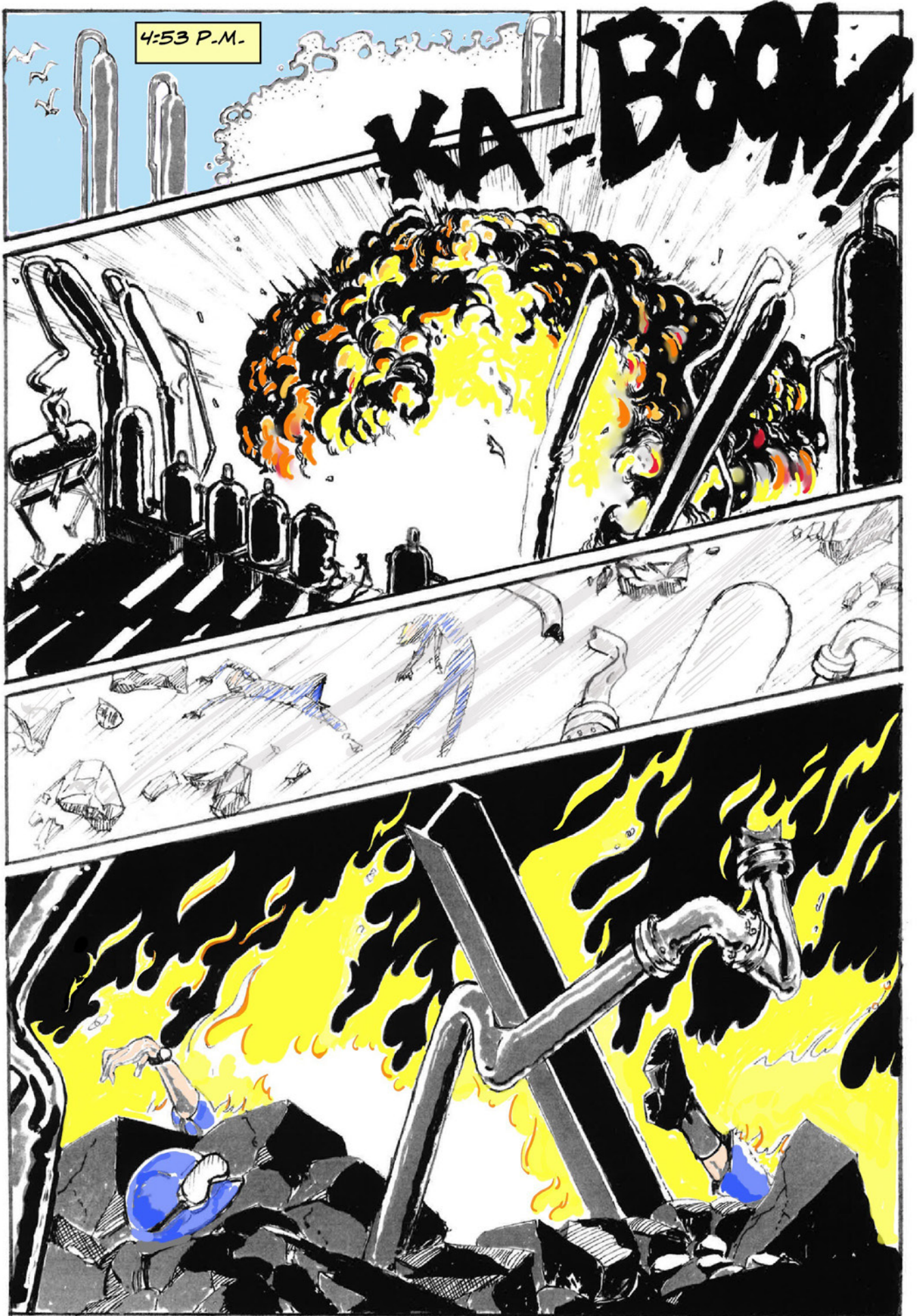


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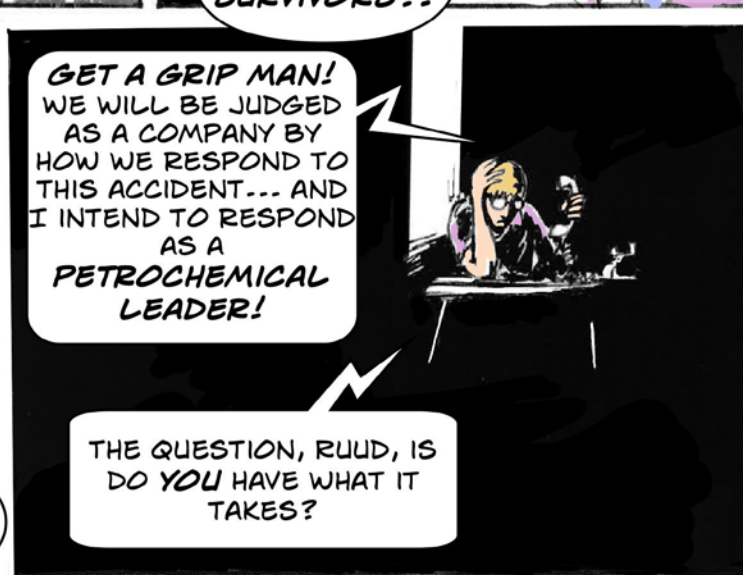
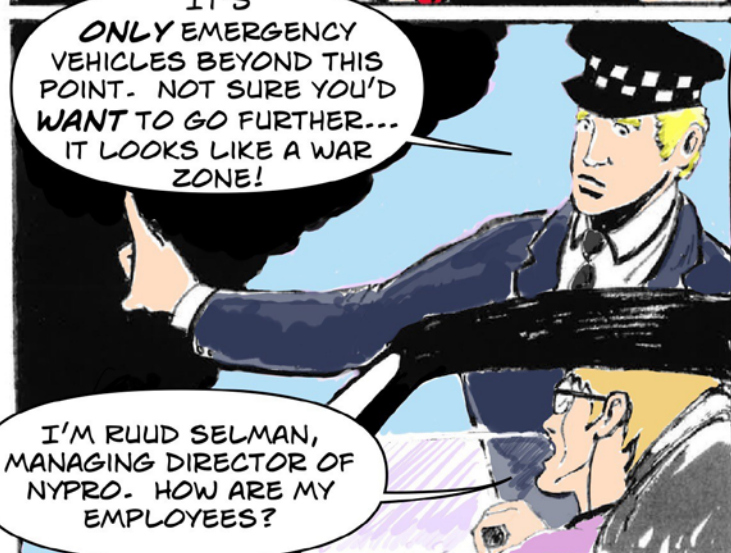
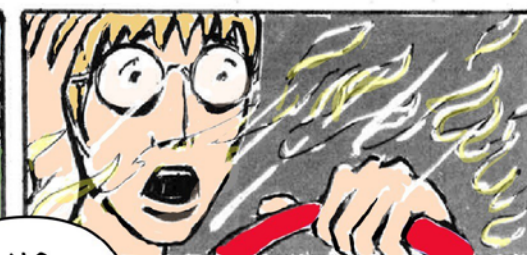
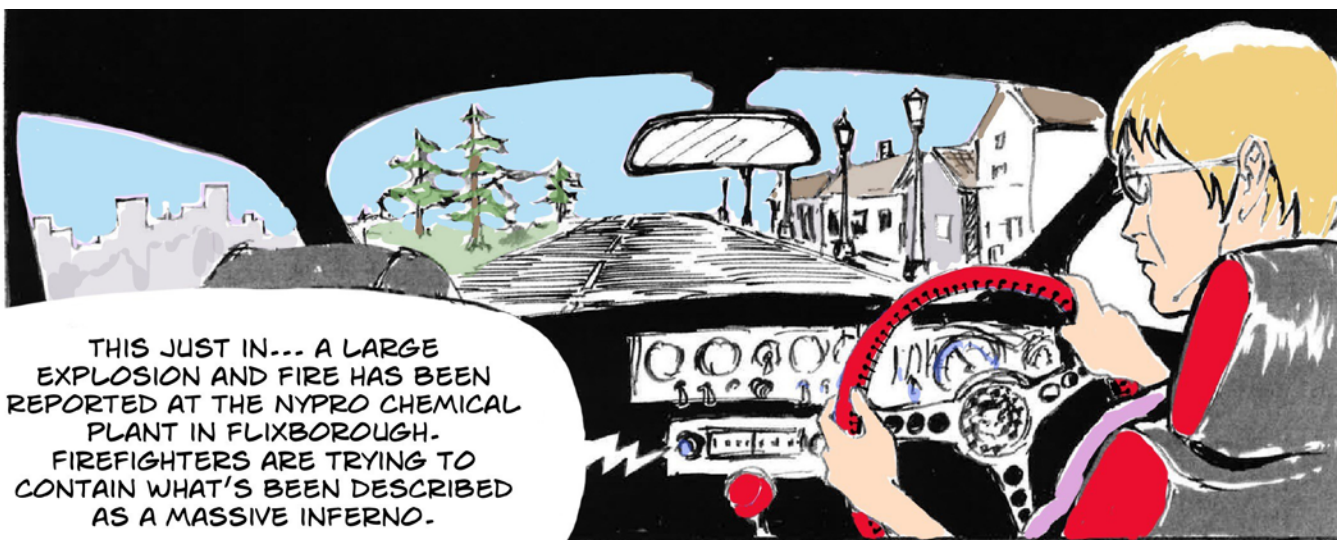




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SHEFFIELD, 3 JUNE



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EPILOGUE
28 fatalities



JAMES DOHERTY, 46, CAME TO NYPRO IN MAY 1972 AFTER LEAVING HIS HOMETLAND OF IRELAND BECAUSE OF THE "TROUBLES." JAMES LIVED IN SCUNTHORPE WITH HIS WIFE **ZETTE** AND THEIR CHILDREN, **SHARON**, **HELEN**, AND **DIANE**. HE LIKED GOLF, SEA-FISHING, AND MOTORING.



MICHAEL "NOBBY" CLARK, 26, LIVED IN SCUNTHORPE WITH HIS WIFE **PAMELA** AND THEIR SONS, **GARY** AND **JASON**. MICHAEL WAS A FORMER MEMBER OF THE ROYAL AIR FORCE. HE LIKED TO HANG OUT AT THE DESERT RAT WHERE HE FREQUENTLY ASSISTED BEHIND THE BAR.



WAYNE BRADSHAW, 19, WAS THE YOUNGEST OF THE WORKERS KILLED BY THE BLAST. HIS FATHER **BOB** AND BROTHER **STEPHEN** ALSO WORKED AT NYPRO. WAYNE HAD JUST COMPLETED A PROCESS OPERATOR COURSE AT THE NORTH LINDSEY COLLEGE OF TECHNOLOGY.



GRAHAM RICHARDS, 30, LIVED WITH HIS WIFE **JACKIE** AND TWO SONS, **ANDREW** AND **DAVID**. HE WAS KNOWN AMONG OTHER PROCESS OPERATORS FOR HIS QUIET AND DRY HUMOUR. GRAHAM WAS WORKING TOWARDS A DEGREE IN SOCIOLOGY AND ECONOMICS AT THE OPEN UNIVERSITY.



FREDERICK WATKINSON, 33, JOINED NYPRO IN MAY 1973 AFTER LEAVING CIBA CHEMICALS. FRED AND HIS WIFE **SHEILA** HAD FOUR CHILDREN, THREE GIRLS AND A BOY, ALL UNDER EIGHT YEARS OF AGE. THE FAMILY HAD JUST MOVED TO THEIR NEW HOME THREE DAYS BEFORE THE TRAGEDY.



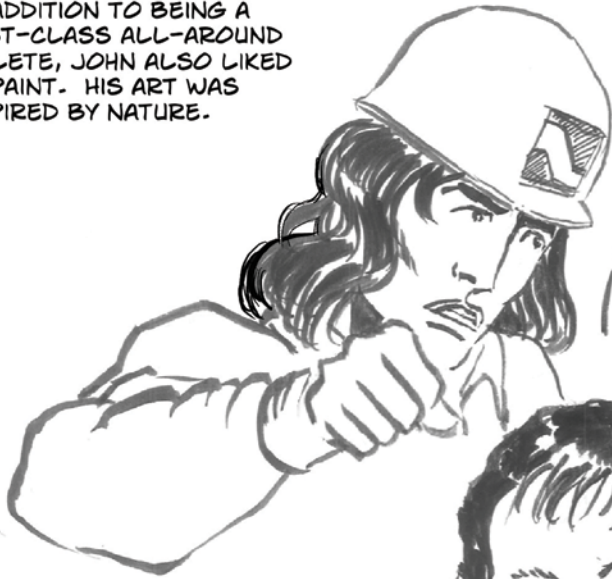
GEOFFREY MARSHALL, 20, LIVED IN SCUNTHORPE. GEOFF WAS A MINE OF INFORMATION ON FOOTBALL TOPICS AND WAS FREQUENTLY CALLED TO SETTLE AN ARGUMENT. HE HIMSELF WAS A KEEN LIVERPOOL SUPPORTER AND HIS MINI WAS DECORATED IN THE COLOURS OF HIS FAVOURITE TEAM- RED AND WHITE! WHENEVER HE COULD FIND TIME HE WOULD ATTEND MATCHES.



THOMAS CROOKES, 53, WORKED AT THE GUARD HOUSE. HE LEFT A WIFE, **HILDA**, AND TWO CHILDREN, **STEPHEN** AND **KAREN**. HIS DUTY COLLEAGUE THROUGHOUT HIS EMPLOYMENT WAS HARRY HOLLAND WHO HIMSELF SUSTAINED INJURY AND LOST HIS SON IN THE DISASTER.

JOHN RENDER, 20, LIVED WITH HIS PARENTS IN BURTON-ON-SATHER. HE WAS ENGAGED TO BE MARRIED TO **JANE HOLMES.** JOHN WAS ONE OF THE STAR PLAYERS WITH BURTON ATHLETIC FOOTBALL CLUB.

IN ADDITION TO BEING A FIRST-CLASS ALL-AROUND ATHLETE, JOHN ALSO LIKED TO PAINT. HIS ART WAS INSPIRED BY NATURE.



MICK HICKSON, 26, JOINED THE COMPANY IN 1967 AS A PROCESS CONTROL TECHNICIAN. HE MET HIS WIFE **MARINA** AT NYPRO. THE TWO LIVED IN FLIXBOROUGH. MICK WAS SERIOUS ABOUT ADVANCING HIS CAREER AND HAD OBTAINED TWO CONTROLS CERTIFICATES. HE WAS INTERESTED IN CAMPING AND HAD JUST BOUGHT A CARAVAN. MICK WAS AN ARDENT SUPPORTER OF LEEDS UNITED.



RONALD FORESTER, 23, LIVED IN SCUNTHORPE WITH HIS WIFE **DENISE** AND THEIR EIGHT MONTH OLD SON, **MARC.** RONALD'S PARENTS AND BROTHER HAD ALSO WORKED AT THE PLANT. RONALD AND DENISE'S SON HAD BEEN CHRISTENED THE SUNDAY BEFORE THE ACCIDENT.



ANTHONY FREEAR, 30, LIVED IN SCUNTHORPE WITH WIFE **JOYCE** AND THEIR SONS, **PAUL** AND **RICHARD.** HE WAS A SKILLED BRICK-LAYER AND WAS IN GREAT DEMAND FOR HIS CUSTOM-BUILT FIREPLACES. TONY WAS PROUD OF HIS RECORD COLLECTION AND HI-FI EQUIPMENT.



EDWIN HOLLAND, 24, LIVED IN SCUNTHORPE WITH HIS WIFE **SHIRLEY** AND THEIR SEVEN MONTH OLD BABY DAUGHTER, **NICOLA JAYNE.** EDWIN HAD JUST LEFT BRITISH STEEL TO WORK FOR NYPRO. HIS FATHER, **HARRY,** SERVED ON THE NYPRO SECURITY STAFF AND WAS ON DUTY THE DAY EDWIN DIED.

KEITH WINTER, 24, LIVED IN SCUNTHORPE WITH HIS WIFE **JILL.** HE JOINED THE COMPANY AFTER GRADUATING FROM **NEWCASTLE UNIVERSITY** WITH A DEGREE IN CHEMICAL ENGINEERING.



ALBERT NUTT, 51, LIVED IN GUINNESS. BEFORE JOINING NYPRO IN FEBRUARY 1973, ALBERT WAS INJURED IN AN INDUSTRIAL ACCIDENT THAT LEFT HIM HANDICAPPED. HE CAME FROM A LARGE FAMILY AND HAD FOUR SURVIVING SISTERS AND BROTHER.

COMIC BOOK



HARRY STARK, 44, LIVED IN SCUNTHORPE WITH HIS WIFE **JESSIE** AND THEIR SONS **COLIN** AND **PAUL**. THEY HAD JUST MOVED IN TO A NEW HOUSE ON BROOK DALE ROAD WHERE HARRY WAS DOING HIS OWN RENOVATION.



ALLAN LAMBERT, 25, WAS HIRED AS A CHEMIST BUT BECAME A PROCESS OPERATOR DURING THE STARTUP OF THE CYCLOHEXANE OXIDATION UNIT. HE WANTED TO ADVANCE HIS TECHNICAL CAREER AND WAS ENROLLED AT THE NORTH LINDSEY COLLEGE OF TECHNOLOGY, PURSUING A DEGREE IN CHEMISTRY.



JOHN BARRETT, 43, LIVED IN KEARNY WITH HIS WIFE **LILIAN** AND THEIR TWO CHILDREN. HIS HOBBY WAS WOODCARVING.



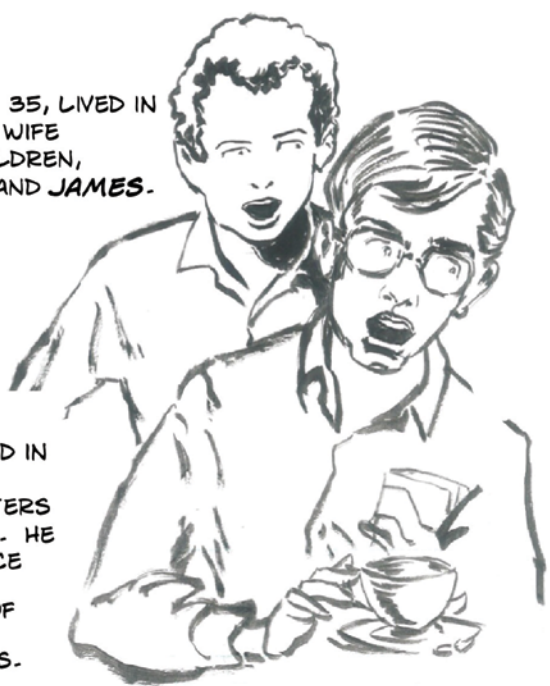
ROLAND CRIBB, 35, LIVED IN SCUNTHORPE WITH HIS WIFE **ZETA** AND THEIR CHILDREN **TREVOR** AND **DIANE**. HE LIKED TO PLAY CRICKET AND WAS A DEDICATED SUPPORTER OF SCUNTHORPE UNITED FOOTBALL CLUB.



TERRY CARTER, 35, LIVED IN FLIXBOROUGH. HE JOINED NYPRO IN 1967 AND WAS PART OF THE ORIGINAL COMMISSIONING TEAM. TERRY WAS ACTIVE IN THE COMPANY SOCIAL CLUB AND ORGANIZED FISHING TRIPS.

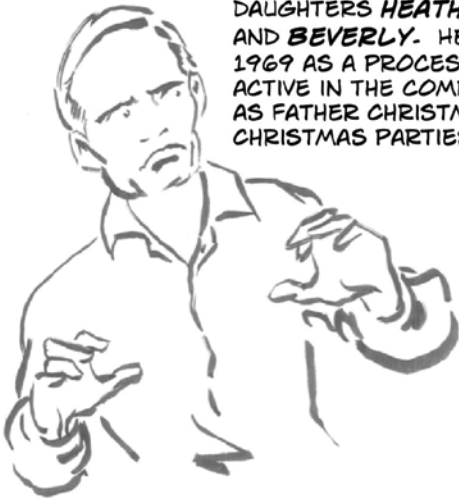
KENNETH CRAWFORD, 35, LIVED IN BOUGHTON WITH WIFE **AGNES** AND CHILDREN, **PAUL, SUSAN,** AND **JAMES**.

HIS HOBBIES INCLUDED GARDENING, FISHING, AND CAR MAINTENANCE.



GEOFFREY TWIDDLE, 30, LIVED IN ASHBY WITH WIFE **PAULINE** AND DAUGHTERS **KAREN** AND **ANGELA**. HE LIKED READING SCIENCE FICTION AND HAD AN INTERESTING HOBBY OF MAKING ELECTRONIC MUSICAL INSTRUMENTS.

DENNIS LAWRENCE, 48, LIVED IN SCUNTHORPE WITH HIS WIFE MARGARET AND DAUGHTERS HEATHER, HILLARY, JACQUELINE, AND BEVERLY. HE JOINED NYPRO IN MARCH 1969 AS A PROCESS TECHNICIAN. DENNIS WAS ACTIVE IN THE COMPANY SOCIAL CLUB, AND ACTED AS FATHER CHRISTMAS AT THE CHILDREN'S CHRISTMAS PARTIES.



THOMAS LEIGHTON, 40, JOINED NYPRO IN JANUARY 1971 AS AN INSTRUMENT TECHNICIAN. HE LIVED IN FLIXBOROUGH WITH WIFE IRENE AND CHILDREN, LINDA, DAVID, AND SUSAN. TOM'S HOBBIES INCLUDED WATCH-REPAIR AND MODEL-MAKING (AMONGST THEM SEVERAL MAGNIFICENT SHIPS.)



STANLEY GRUNDY, 48, LIVED IN BRIGGS WITH WIFE NELLIE A DAY CHILDREN, RUSSELL AND MARK. HE WAS LOADING A TANKER TRUCK AT THE TIME OF THE BLAST.



MICHAEL SKELTON, 27, LIVED IN FLIXBOROUGH WITH HIS WIFE LESLEY CHRISTINE. HE WAS PREVIOUSLY A BREAD SALESMAN AND WELL RESPECTED IN THE COMMUNITY.



STEPHEN DRURY, 27, LIVED IN BURTON-ON-SLATHER WITH WIFE SUSAN AND ONLY DAUGHTER SAMANTHA. HE JOINED NYPRO IN JUNE 1973 AS A PROCESS OPERATOR. STEVE WAS QUIET AND ENJOYED "DO-IT-YOURSELF" PROJECTS AROUND THE HOUSE.



RICK SIMPSON, 34, LIVED IN SCUNTHORPE. HE WAS DIVORCED WITH TWO CHILDREN. AT THE TIME OF THE ACCIDENT, RICK WAS ENGAGED TO MARRY VANESSA DALY. HE WAS THE SHIFT SUPERINTENDENT AND HAD ATTENDED TRAINING AT THE DSM PETROCHEMICAL COMPLEX IN GELEEN, HOLLAND.



IAN KIDNER, 37, LIVED IN SCUNTHORPE WITH WIFE MARION AND CHILDREN ADELE AND JOHN. HE CAME TO NYPRO IN JULY 1966 AFTER LEAVING THE STEEL INDUSTRY. IAN HAD SERVED IN THE ROYAL AIR FORCE AND WAS AN EXCELLENT INSTRUMENT TECHNICIAN.



References

Opening Page: Quotation was found in the book from Laird Wilson.

Wilson, L.; McCutcheon, D. *Industrial Safety and Risk Management*; The University of Alberta Press: Edmonton, 2003; p 89.

Pages 1-3: We know today that the DuPont research scientist and inventor of nylon, Wallace Carothers, suffered from clinical depression. An account of DuPont's inconsistent handling of his legacy is given by Sam Knight in the article entitled, "The Tragic Story of Wallace Hume Carothers."

Knight, S. *FT Magazine*; Nov. 29, 2008. (Available online at www.FT.com)

Pages 3, 5: Lamot du Pont II was the company's president during development and commercialization of nylon. Nylon is the most important of the many chemical products DuPont has developed and commercialized-- both in terms of earnings for the company and transformative impact on society. As described in the book by Pap Ndiye, the company recognized the polymer's potential very early.

Ndiaye, Pap A. *Nylon and Bombs: DuPont and the March of Modern America*, The John Hopkins University Press: Baltimore, 2007; pp. 90-105.

Pages 5, 8: Synthesis of nylon from caprolactam by the German company I.G. Farben (the Nazi-era predecessor to BASF) provided an elegant route around the DuPont patents. Images of the original nylon patents are taken from the website www.freepatentsonline.com .

Nylon-6 production in Germany began soon after nylon-6,6 in America. DSM's strategic decision to become the leading producer of caprolactam in post-war Europe is described in the book by Arjan van Rooij.

van Rooij, A. *The Company That Changed Itself: R&D and Transformations of DSM*; Amsterdam University Press: Amsterdam, 2007; pp 82-98.

Page 6: The backdrop in this page is based on an early-1970's magazine ad by British Enkalon.

Page 7: The "market pull" for caprolactam and nylon-6 in U.K. came from textile companies like Courtaulds eager to end the single-supplier situation with nylon-6,6. This is described in the 1961 article in *Chemical & Engineering News* entitled, "Britain Swings to Nylon 6."

Chem. Eng. News, June 19, 1961; p 35.

Pages 7, 8, 13: The chemical market dynamics that drove development of the cyclohexane oxidation process (for production of caprolactam intermediate cyclohexanone) is described in the following articles from 1966 and 1967. The first one describes concerns that the projected phenol supply growth is insufficient to meet caprolactam demand, while the second reports on advances in cyclohexane oxidation technology.

Chem. Eng. News, June 6, 1966; pp 17-18.

Chem. Eng. News, Aug. 28, 1967; pp 82-88.

Page 21: The clipping pasted is from the *Chemical & Engineering News* article entitled, "Demand for caprolactam spurs expansions" (© 1973, American Chemical Society)

Chem. Eng. News, July 23, 1973; pp 6-7.

Pages 22-23, 29-31, 33-36: The sequence of events that preceded the reactor failure of March 27, 1974, are described in Ralph King's book, and his later article in *Process Engineering*.

King, R. *Safety in the Process Industries*; Butterworth-Heinemann: London, 1990; Chapter 4.

King, R. *Process Engineering*, Jan. 15, 2000.

(Available online at www.processengineering.co.uk.)

Pages 26-28: The music lyrics are from the songs, "Twist and Shout" (written by Phil Meldly and Bert Berns) and "While My Guitar Gently Weeps" (written by George Harrison).

Page 38: The fact that the dogleg pipe was drawn on the shop floor (instead of as a formal engineering drawing submitted for review and approval, before issue for construction) has been brought up by Trevor Kretz to illustrate how poorly this process change was managed by Nypro.

Kletz, T. *What Went Wrong?: Case Histories of Process Plant Disasters and How They Could Have Been Prevented*; Elsevier: New York, 2009; pp 53-54.

Page 42: The dogleg pipe drawn here is based on the illustration of the same in the Court of Inquiry report.

The Flixborough disaster: Report of the Court of Inquiry; Department of Employment. Her Majesty's Stationery Office: London, 1975.

Page 44-48: The chronology of events immediately preceding the June 1 explosion are from the Court of Inquiry report (cited above).

Page 55: The collage of newspapers includes Scunthorpe *Evening Telegraph*, Briggs *Star*, and Hull *Daily Mail*.

Pages 56-59: The obituary of the workers killed during the blast was found on The Glebe Blog (<http://jimzglebeblog.blogspot.com>).