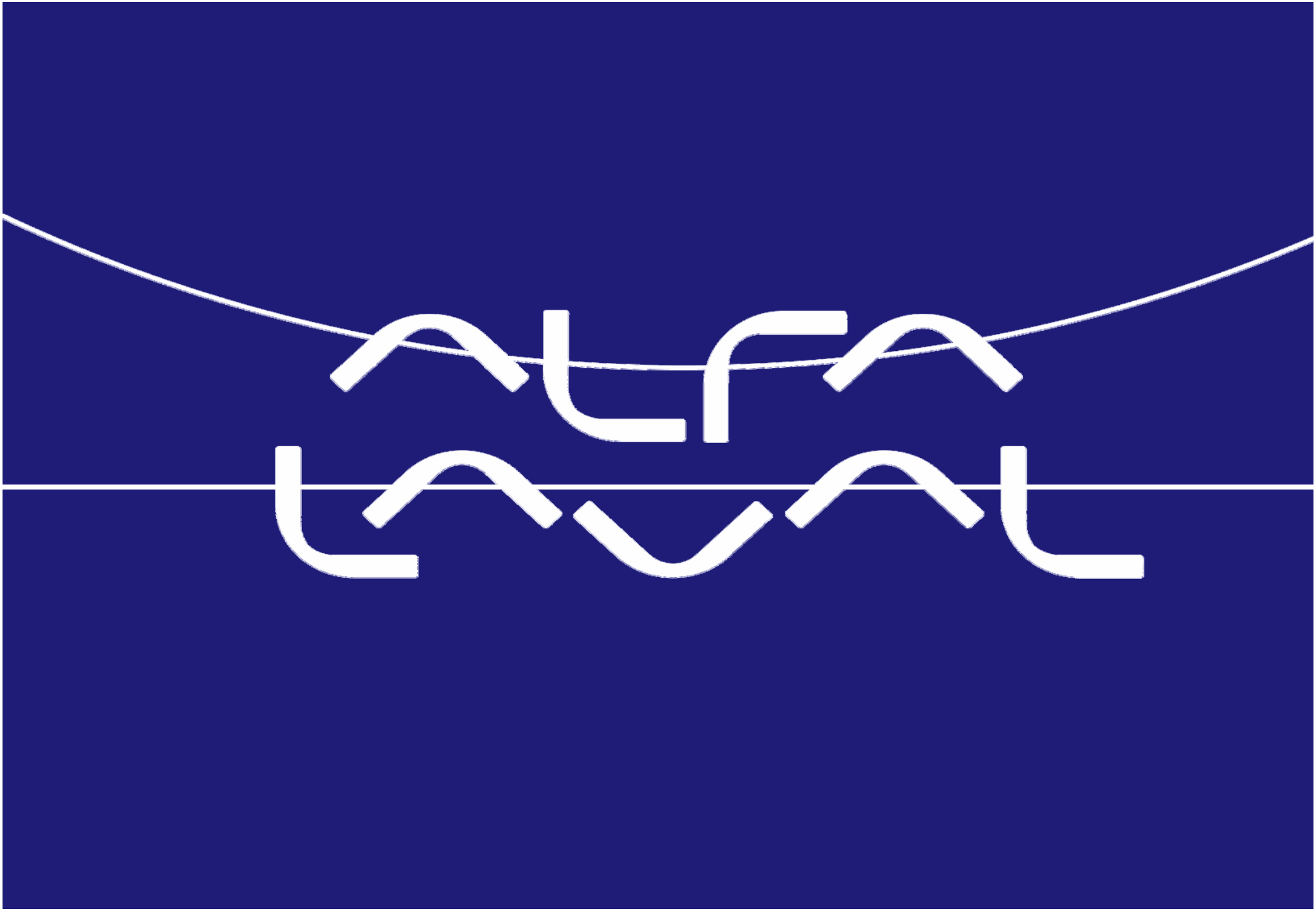
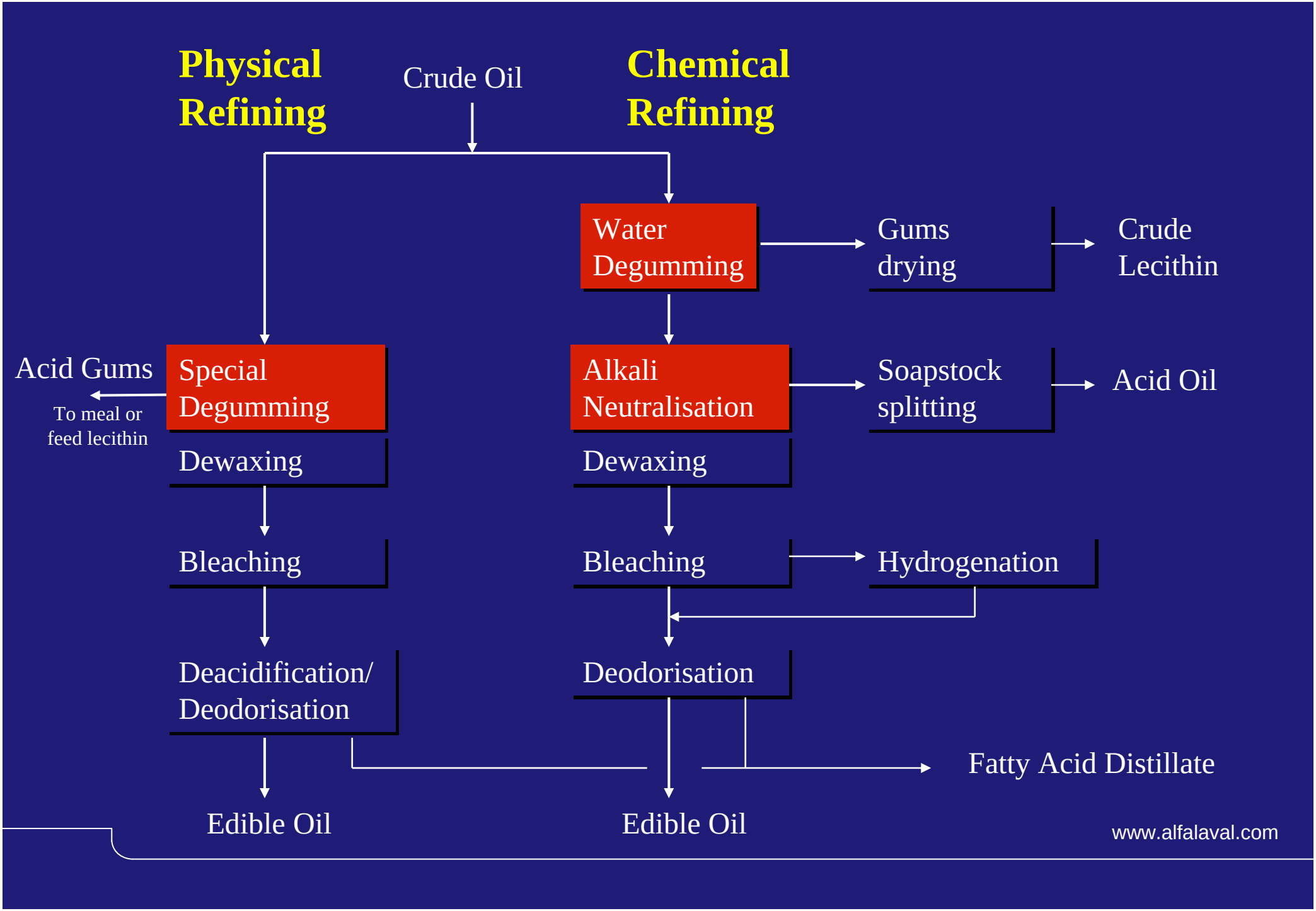

ALFA
LAVAL

Review of Degumming and Refining Technologies

Andrew Logan
Alfa Laval Copenhagen A/S


Physical Refining
Crude Oil
Chemical Refining
Water Degumming
Gums drying
Crude Lecithin
Acid Gums
To meal or feed lecithin
Special Degumming
Alkali Neutralisation
Soapstock splitting
Acid Oil
Dewaxing
Dewaxing
Bleaching
Bleaching
Hydrogenation
Deacidification/ Deodorisation
Deodorisation
Fatty Acid Distillate
Edible Oil
Edible Oil
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Physical Refining

Feedstock Parameters

- Seed Oil (Soybean, Rapeseed, Sunflower)
  - FFA ≤ 2%
    - higher FFA indicates low quality oil and may not be suitable for physical refining
  - Phosphorous ≤ 5 ppm, ≤2 desired
  - Iron ≤ 0.2 ppm

Chemical Refining

Feedstock Parameters

- Seed Oil (Soybean, Rapeseed, Sunflower)
  - FFA ≤ 3%
  - Phosphorous ≤ 1200 ppm, ≤ 200 ppm desired

Purpose of Degumming

- Commercial Lecithin production
- Prevent crude oil settling during storage or transport
- Waste water (prevent acidulation of gums)
- Physical Refining
- Reduction in neutralisation losses

Gums

- Two main types
  - Hydratable Phosphatides - easy to remove
  - Non-Hydratable Phosphatides (NHP) - hard to remove from oil
    - Some NHP removed with hydratables in water degumming
    - requires the use of a acid to convert to hydratable for complete removal

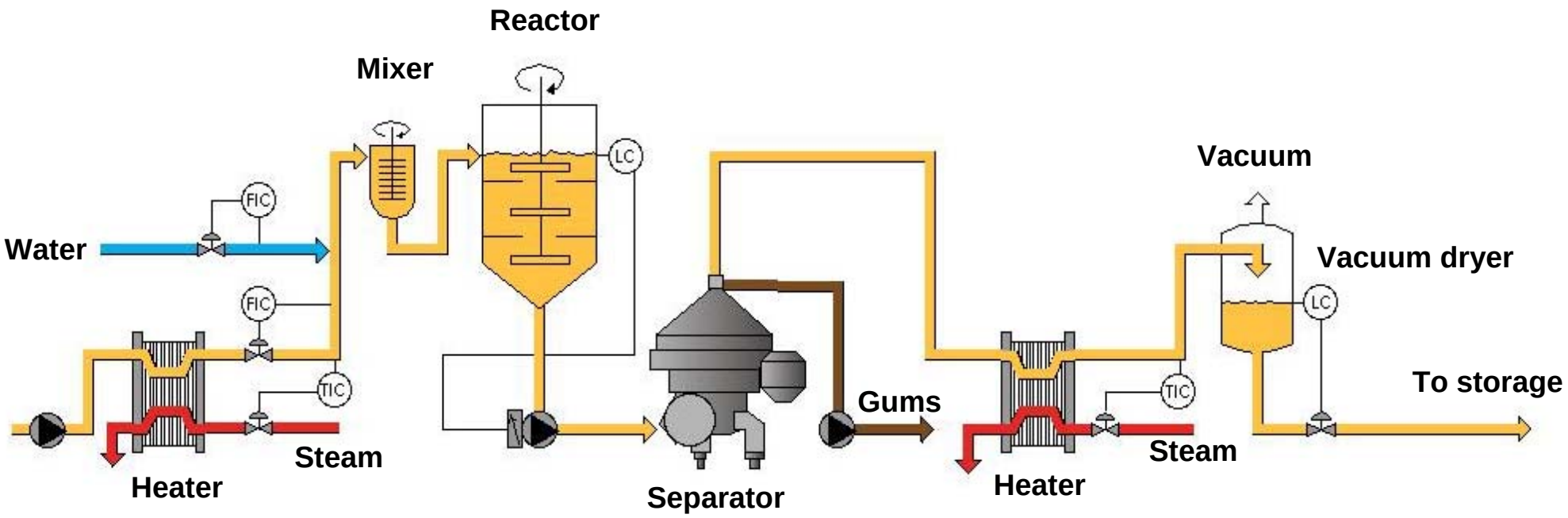
Gum content of various oils

Oil type	Phosphatides (%)	Phosphorus (ppm)
Coconut	0.02 – 0.05	10 – 20
Corn	0.7 – 2.0	250 – 800
Cottonseed	1.0 – 2.5	400 – 1000
Groundnut	0.3 – 0 .7	100 – 300
Palm	0. 03 – 0.1	15 – 30
Rapeseed	0.5 – 3.5	200 – 1400
Soya	1.0 – 3.0	400 – 1200
Sunflower	0.5 – 1.3	200 – 500

Water Degumming Process Steps

- Heat oil to 60 - 70 °C
- Water addition and mixing
- Hydration mixing 30 minutes
- Centrifugal separation of hydrated gums
- Vacuum drying of degummed oil
- Gums - dried for edible lecithin or recombined in meal

Water Degumming



Water Degumming

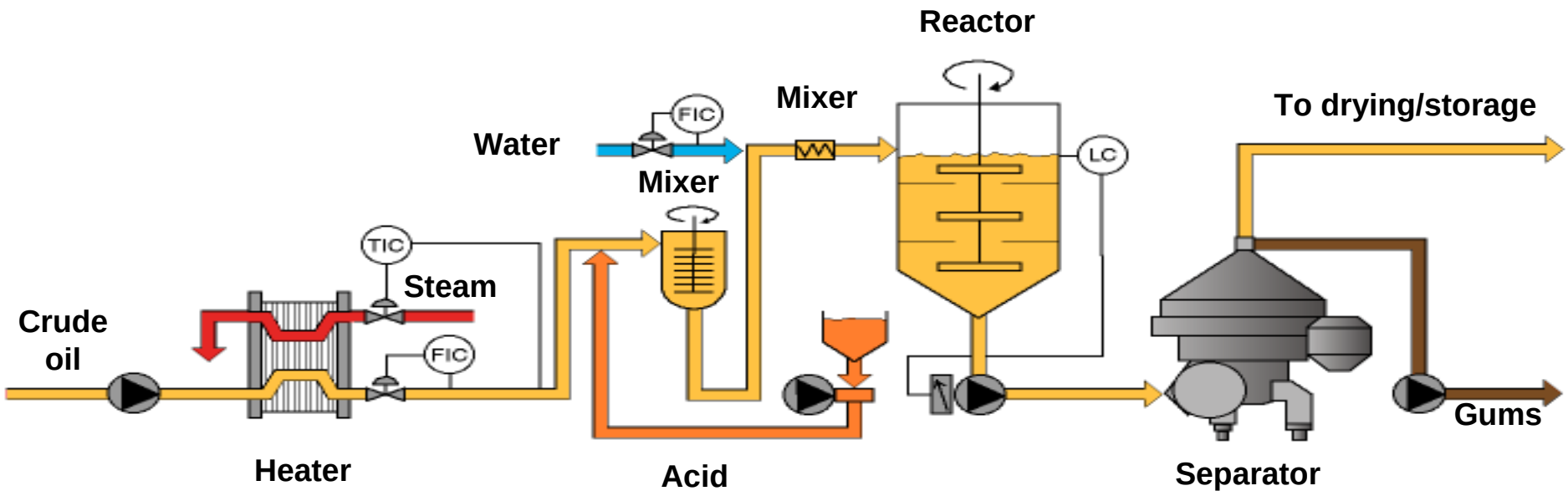
Target Results

- Phosphorous in oil - 50 to 200 ppm max.
- AI% in dried gums - 65 to 70%
- Moisture in dried oil - < 0.1%

Acid Degumming Process Steps

- Heat oil to 60 - 70 °C
- Acid addition and mixing
- Hydration mixing 30 minutes
- Centrifugal separation of hydrated gums
- Vacuum drying of degummed oil
- Gums - recombined in meal

Acid Degumming



Acid Degumming

Target Results

- Phosphorous in oil - 20 to 50 ppm max.
- AI% in dried gums - 65 to 70%
- Moisture in dried oil - < 0.1%

Major Deep Degumming Methods

- Alfa Laval Special Degumming
- Super/Uni Degumming
- TOP Degumming
- Organic Refining Process
- Soft Degumming
- Enzymatic Degumming

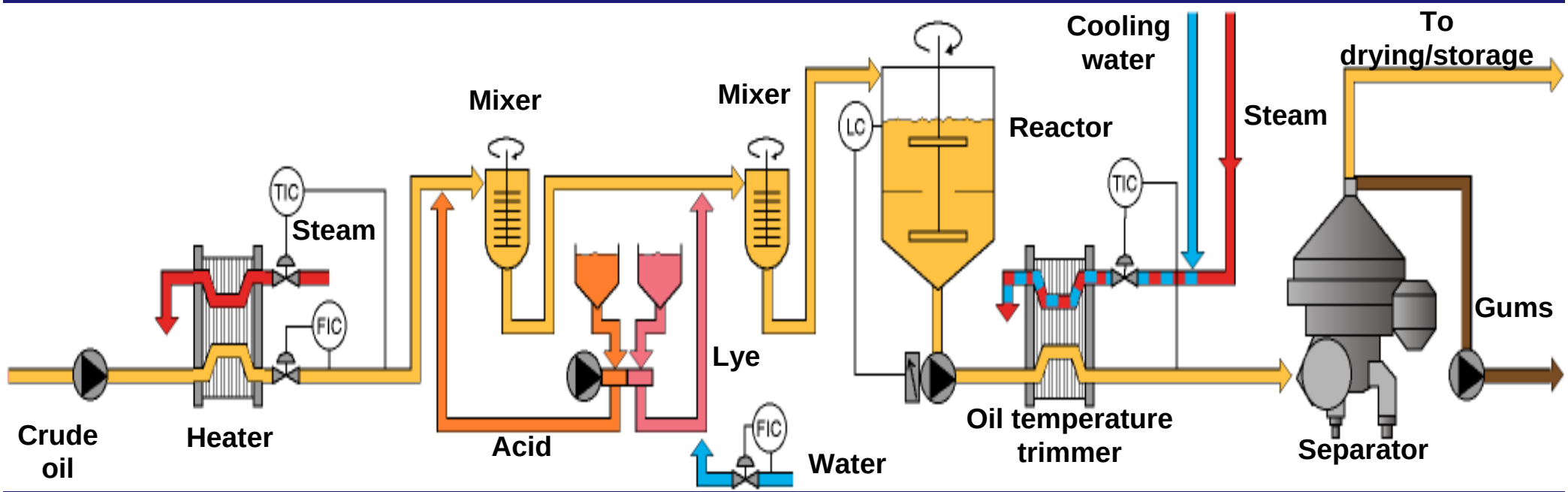
Deep Degumming

- Deep degumming utilizes a reagent like acid to chelate Iron, Calcium, and Magnesium away from the NHP complex. Once the Iron, Calcium, and Magnesium are removed from the NHP complex the phosphatide becomes hydratable
- Enzymatic degumming utilizes an enzyme to modify the NHP into a hydratable form.

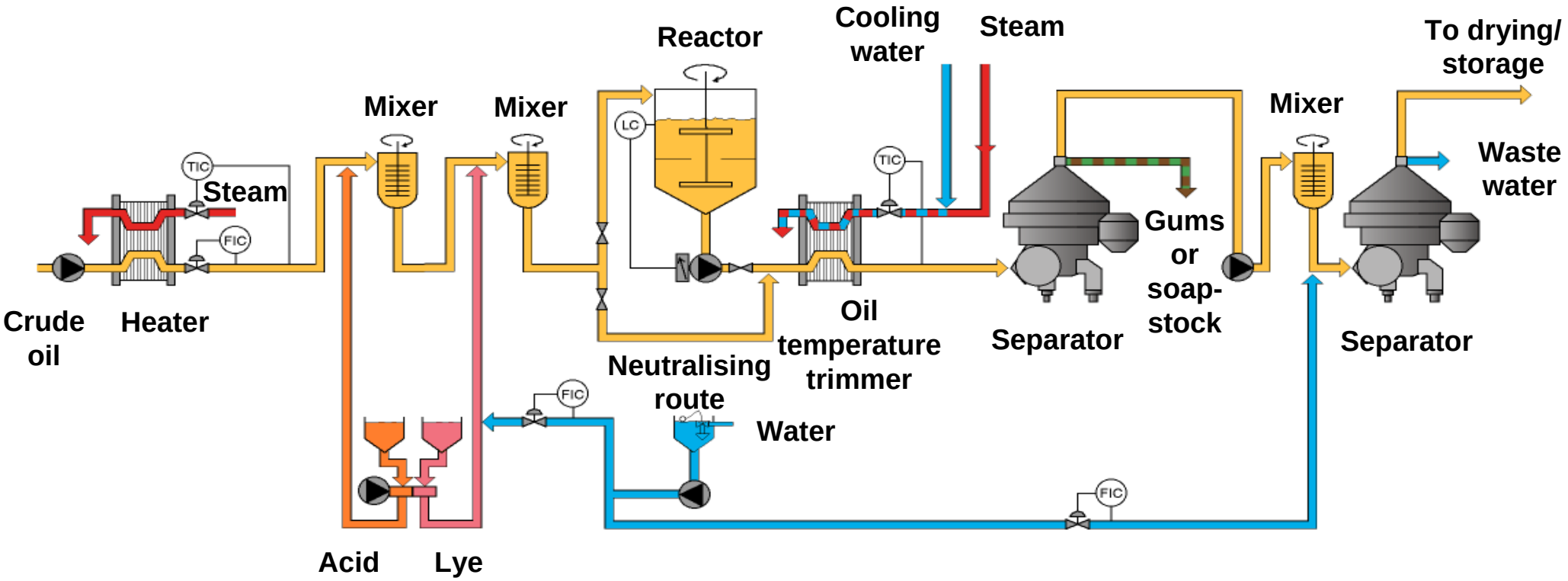
Alfa Laval Special Degumming

- Heat oil to 60 ^{o}C
- 0.05-0.2 % Phosphoric Acid with intensive mixing
- Partially neutralise with dilute lye (hydration water)
- Gentle mixing and holding for 60 minutes
- Gums centrifugation
- Optional water wash step for lower phosphorous
- Oil drying

Alfa Laval Special Degumming



Alfa Laval 2-stage Special Degumming



Alfa Laval Special Degumming

Target Results

- Phosphorous in oil - 20 to 30 ppm max.
- Phosphorous in oil - 8 to 10 ppm max. with washing
- AI% in dried gums - 50 to 60%
- Moisture in dried oil - < 0.1%

Deep Degumming Results

Process	Phosphatides (%)	Phosphorus (ppm)
Special Degumming	< 0.02	< 10
Super/Uni Degumming	0.01 – 0.04	5 – 15
TOP Degumming	0.01 – 0.02	5 – 10
Soft Degumming	< 0.01	< 5
ORP	< 0.02	< 10
Enzymatic Degumming	0.01 – 0.02	5 – 10
Ultrafiltration	< 0.01	< 5

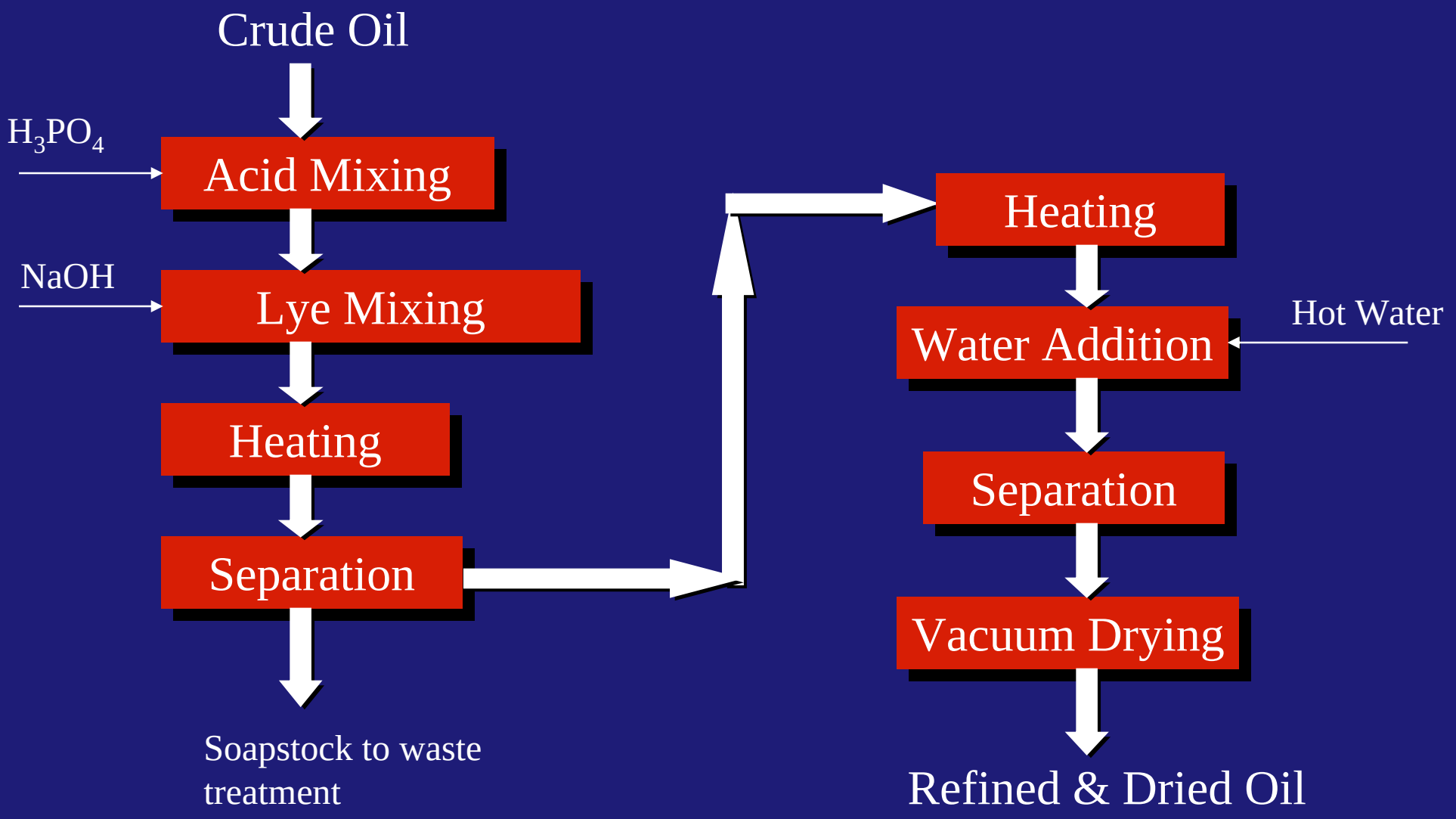
Purpose of Alkali Refining

- Removing of impurities from oil
  - Phospholipids (gums)
  - Colour bodies
  - Metal Ions - Pro-oxidants
    - Iron
    - Copper
  - Free Fatty Acids
  - Solids - meal fines

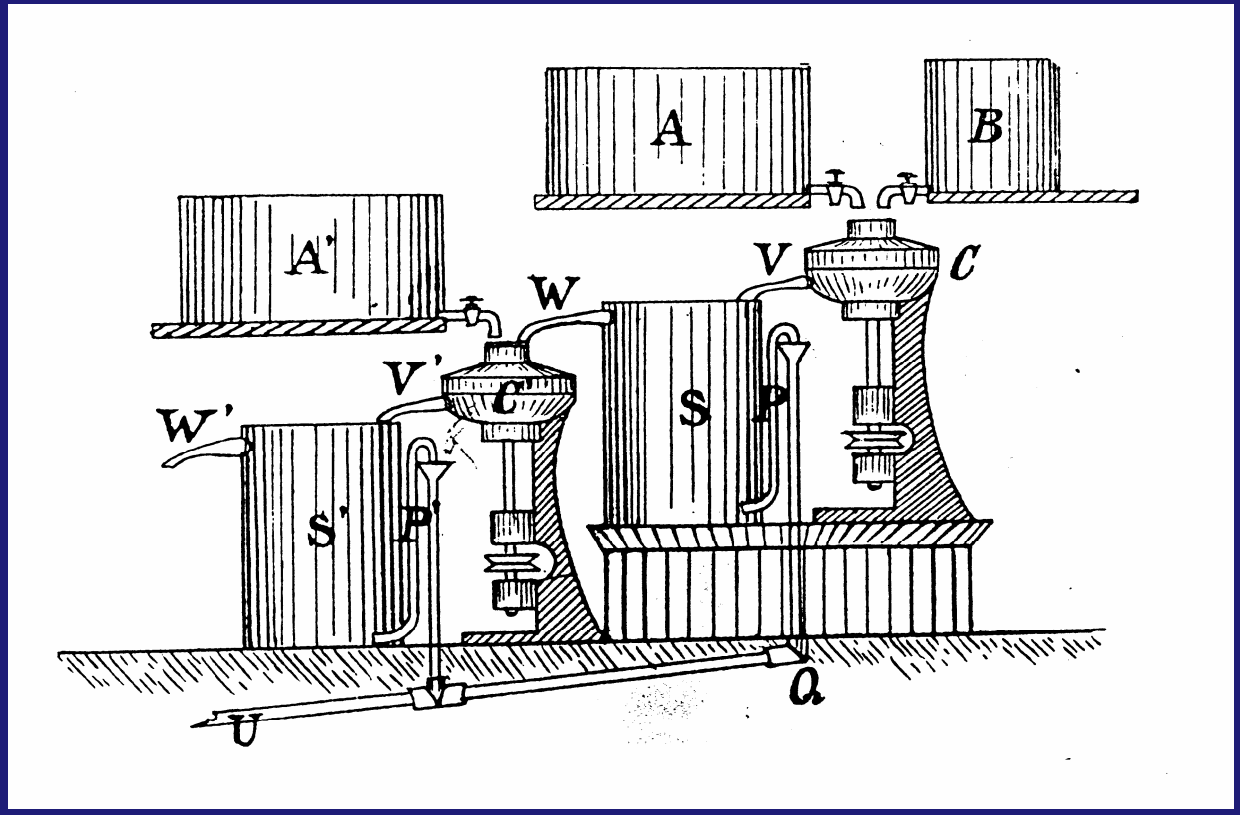
Oil Impurities

- Phospholipids
  - cause emulsions
  - darken oil with heat
  - interfere with crystallization
- Colour Bodies
  - Some have nutritional value
  - Remove to add consumer appeal & functionality in industrial uses (not heat stable)
- Metal Ions
  - act as pro-oxidants degrading the oil quality & stability

Alkali Refining Process Steps



Alkali Refining Plant - ca. 1892



Neutralization Reaction

Fatty Acid Caustic Soda Soap

Other mechanisms

- colour bodies adsorbed onto soap
- phosphatides hydrated by water in lye
- chelated metal ions removed in soap

Effect of Lye Excess

- Groundnut oil with 2,5 % FFA refined with 4,25 N lye

Lye excess (%)	FFASS (%)	Refining factor (excl. saponification)	Real refining factor (incl. saponification)
5	55	1,82	1,86
40	75	1,33	1,61
80	80	1,25	1,81

Effect of Acid Conditioning

Oil	Amount of acid % w/w	Soap content (ppm)		P – content (ppm)	
		Neutral-ised oil	Washed oil	Crude oil	Washed oil
Rapeseed	0	1900	1200	250	180
”	0,15	1500	80	250	5
Sunflower	0	1600	500	320	90
”	0,05	1400	50	320	2
Corn	0	2100	1500	540	120
”	0,10	1100	80	540	4
Soybean	0	700	120	90	20
”	0,10	600	40	90	2

Washing and Drying

- Washing

  - Hot soft process water should be used

  - 5 -10 % of oil flow

- Drying

  - 70 mm Hg vacuum

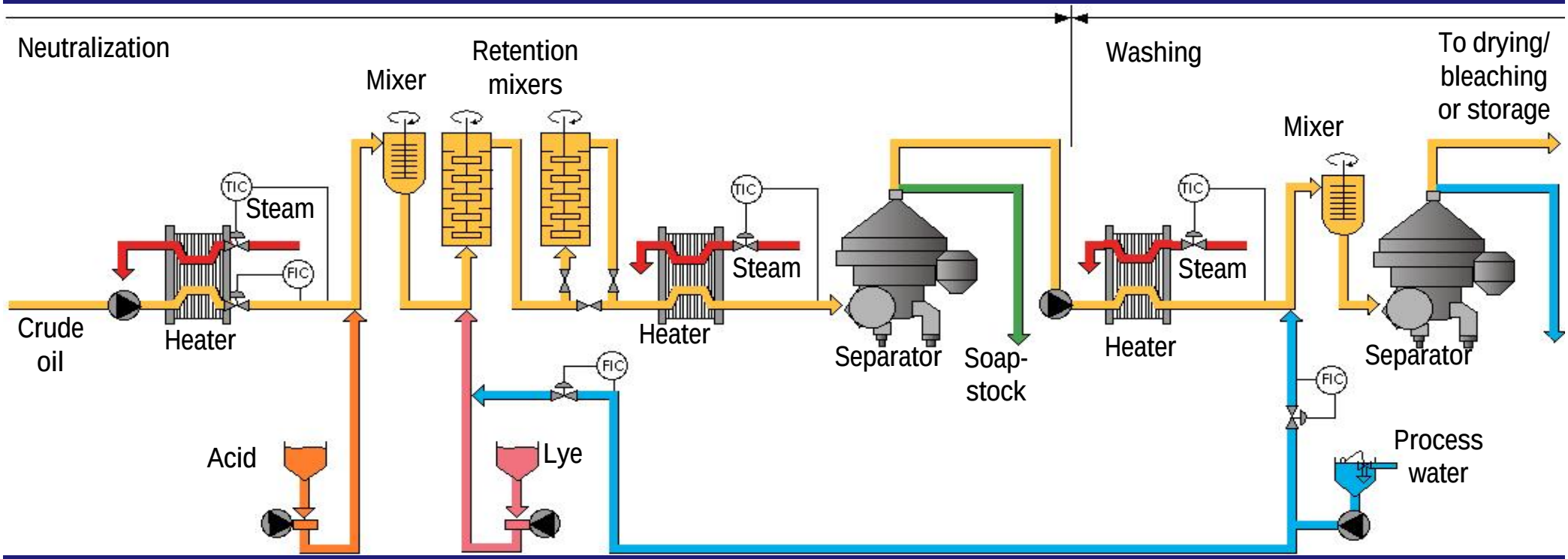
Refining Process - Selection

		P - content	
		< 200 ppm	> 200 ppm
FFA	< 1,5 %	Long-Mix or Multi-Mix	Long-Mix
	1,5 – 3 %	Multi-Mix (2-stage)	Multi-Mix (3-stage)
	> 3 %		

Long-Mix Process Steps

- Acid pre-treatment
- Lye mixing
- Retention mixing
- Emulsion break heating
- Centrifugal separation of soapstock
- Heat
- Water addition and mixing
- Centrifugal separation of wash water
- Vacuum drying of refined and washed oil

Long-Mix Process



Long-Mix – Lye Treat Conditions

	Strength (°Bé)	Excess (%)	Reaction time (min)
Crude seed oils	14 - 22	70 - 100	3 – 6
Degummed seed oils	16 - 26	35 - 70	2 – 5
Cottonseed	18 - 36	70 - 200	6 – 10
Corn	18 - 20	35 - 100	1 - 2

Long-Mix

Target Results

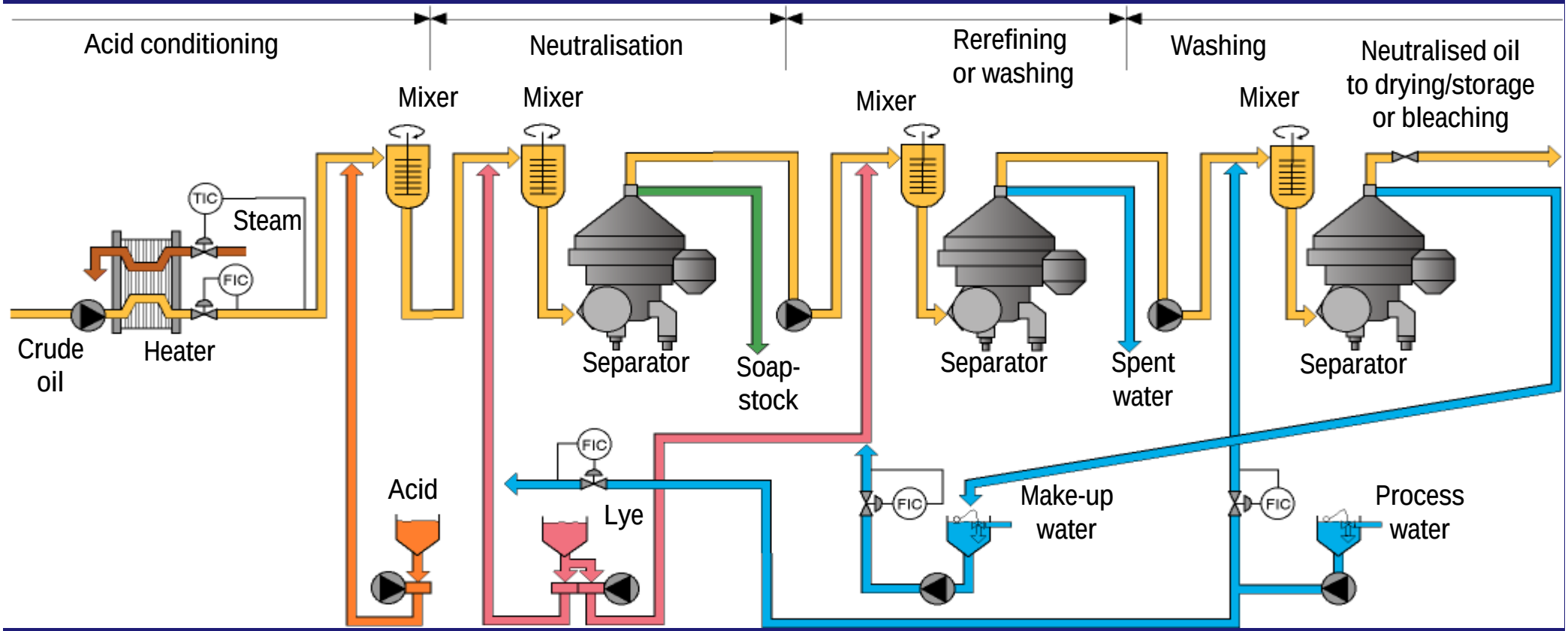
- Phosphorous in oil after S1 - 8 to 12 ppm, 20 ppm max.
- Soap in oil after S1 - 200 to 300 ppm, 400 ppm max.

- Phosphorus in oil after S2 – max. 4 ppm
- Soap in oil after S2 – max. 50 ppm
- FFA in oil – 0,02 to 0,04 %, 0,05 % max.
- Moisture in oil – max. 0,5 % or 0,05% if dried
- Loss = max. 0,8 + 1,25 x TL

Multi-Mix Process Steps

- Heat
- Acid pre-treatment
- Lye mixing
- Centrifugal separation of soapstock
- Lye or water mixing
- Centrifugal separator of soapstock or wash water
- Water addition and mixing
- Centrifugal separation of wash water
- Vacuum drying of refined and washed oil

Multi-Mix Process



Multi-Mix – Lye Treat Conditions

	Strength (°Bé)	Excess (%)	Reaction time (sec)
Crude seed oils	20 - 28	30 - 60	15 - 30
Degummed seed oils	20 - 28	10 - 30	1 - 3
Cottonseed	20 - 28	10 - 50	>1
Anaimal & Fish	20 - 28	10 - 30	1 - 3

Multi-Mix

Target Results

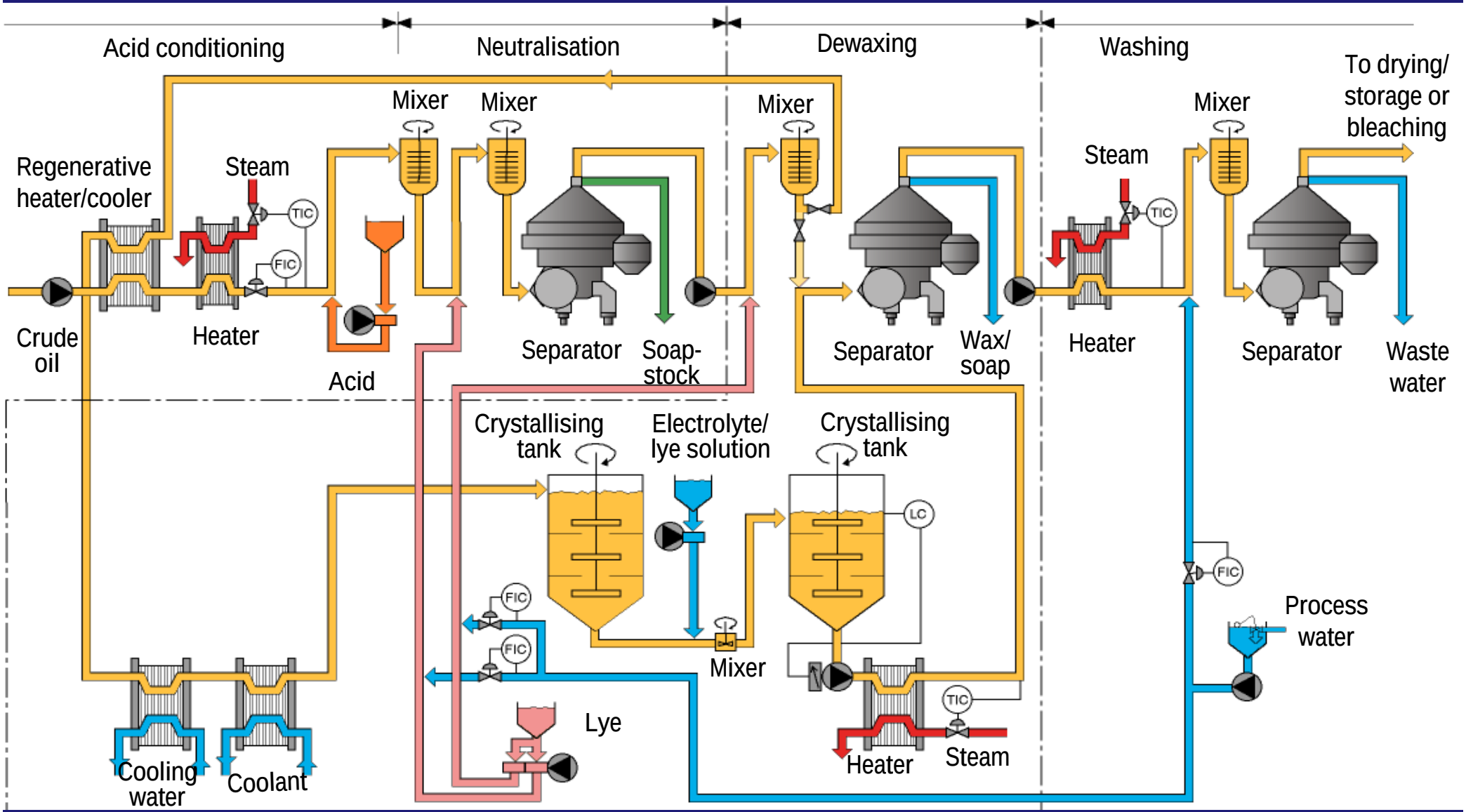
- Phosphorous in oil after S1 - 8 to 12 ppm, 20 ppm max.
- Soap in oil after S1 - 500 to 700 ppm, 1000 ppm max.

- Phosphorus in oil after S3 – max. 4 ppm
- Soap in oil after S3 – max. 30 ppm
- FFA in oil – 0,02 to 0,04 %, 0,05 % max.
- Moisture in oil – max. 0,5 % or 0,05% if dried
- Loss = max. 0,3 + 1,25 x TL (+ 0,3 % if re-refining)

Multi-Wax Process Steps

- Heat
- Acid pre-treatment
- Lye mixing
- Centrifugal separation of soapstock
- Lye mixing
- Cool
- Crystallization
- Heat
- Centrifugal separator of waxes and soapy water
- Heat
- Water addition and mixing
- Centrifugal separation of wash water
- Vacuum drying of refined and washed oil

Multi-Wax Process



Multi-Wax

Target Results

- Soap in oil after S1 - 1500 to 2000 ppm, 2500 ppm max.

- Phosphorus in oil after S3 – max. 4 ppm
- Soap in oil after S3 – max. 50 ppm
- Wax removal – min. 85 %
- FFA in oil – 0,02 to 0,04 %, 0,05 % max.
- Moisture in oil – max. 0,5 % or 0,05% if dried
- Loss = max. 0,7 + 1,25 x TL for 600 ppm wax content or
  max. 1,2 + 1,25 x TL for 1500 ppm wax content

Other Refining Process

- Cold neutralization

  - combined neutralization and dewaxing

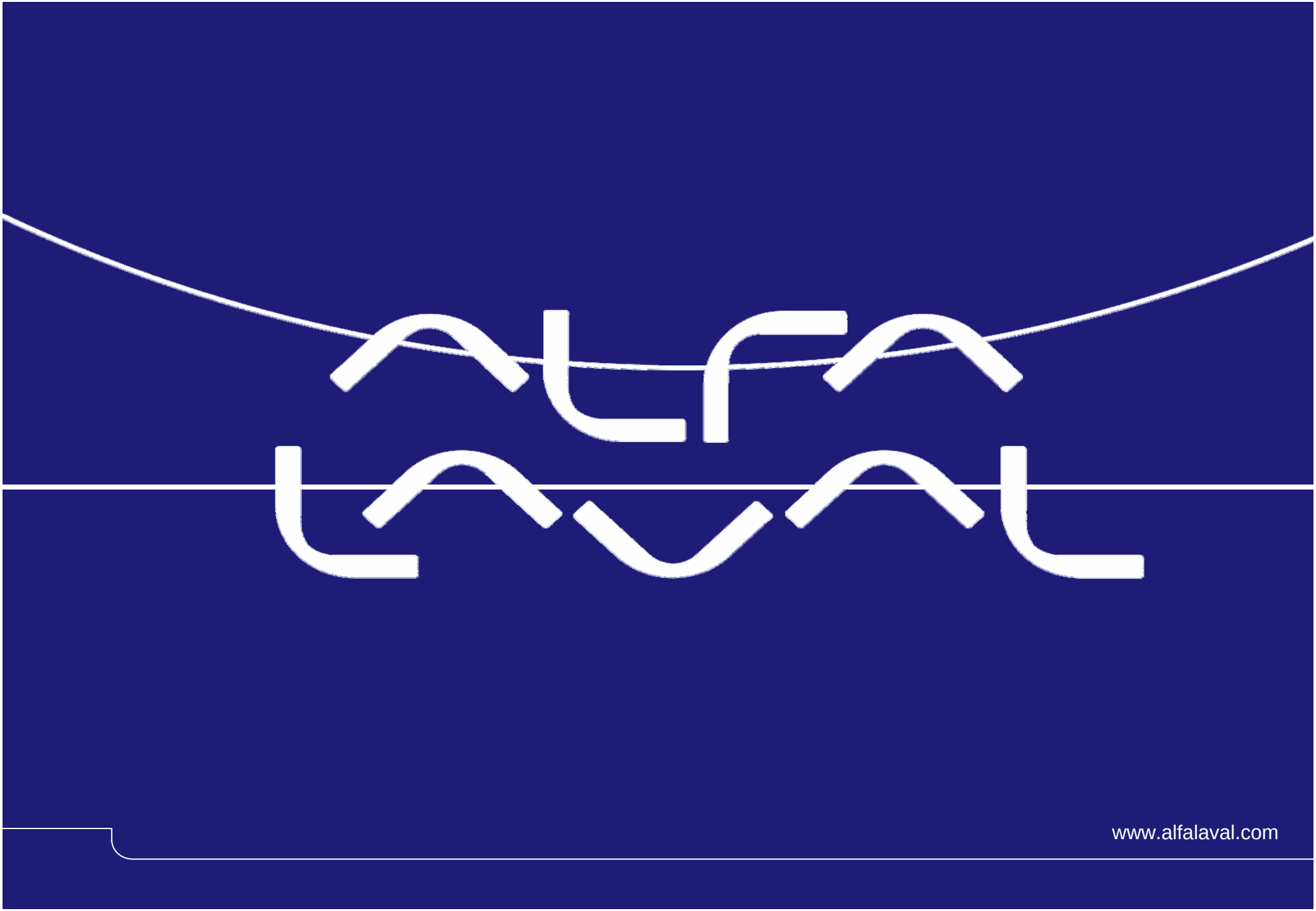
- Miscella refining

  - neutralization in the miscella phase

- Modified Caustic Refining (MCR)

Dry Refined Oil Quality Targets

- Soap - < 30 ppm
- Phosphorous - < 2 ppm
- Iron - < 0.2 ppm
- Copper - < 0.01 ppm
- FFA - < 0.05%
- Moisture - < 0.05%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