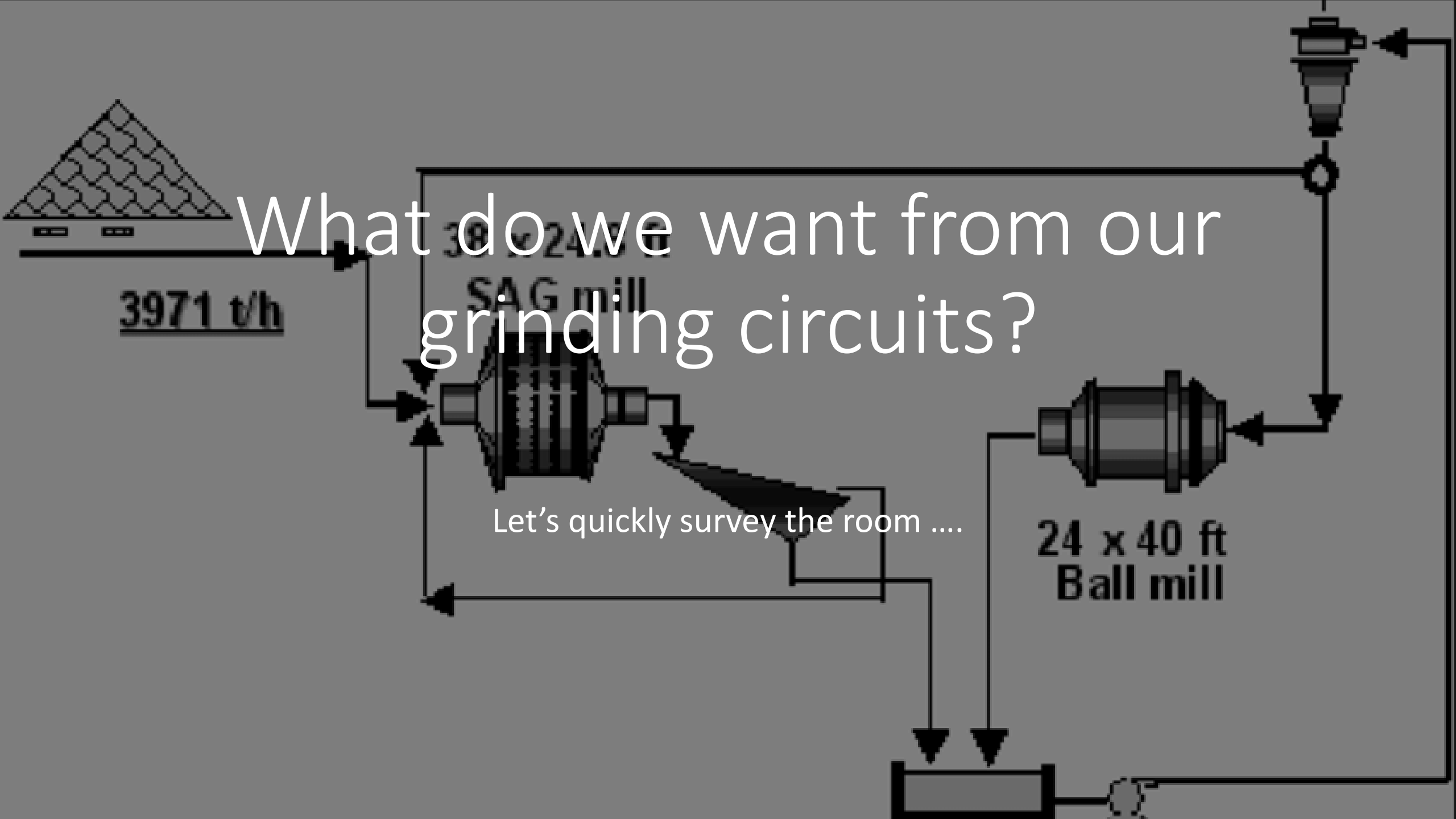
Grinding Circuit Classification

Have we got it all wrong …… ?

What do we want from our grinding circuits?



Let’s quickly survey the room ….

Maybe some answers from the room have been …..

- To generate a p80
- To minimise cost of milling
- To be energy efficient
- To be easy to operate
- To be able to handle a wide variety of ore types

- Others ….?

For me ….. the primary objective of any crushing and grinding circuit is to prepare ore for downstream metal recovery

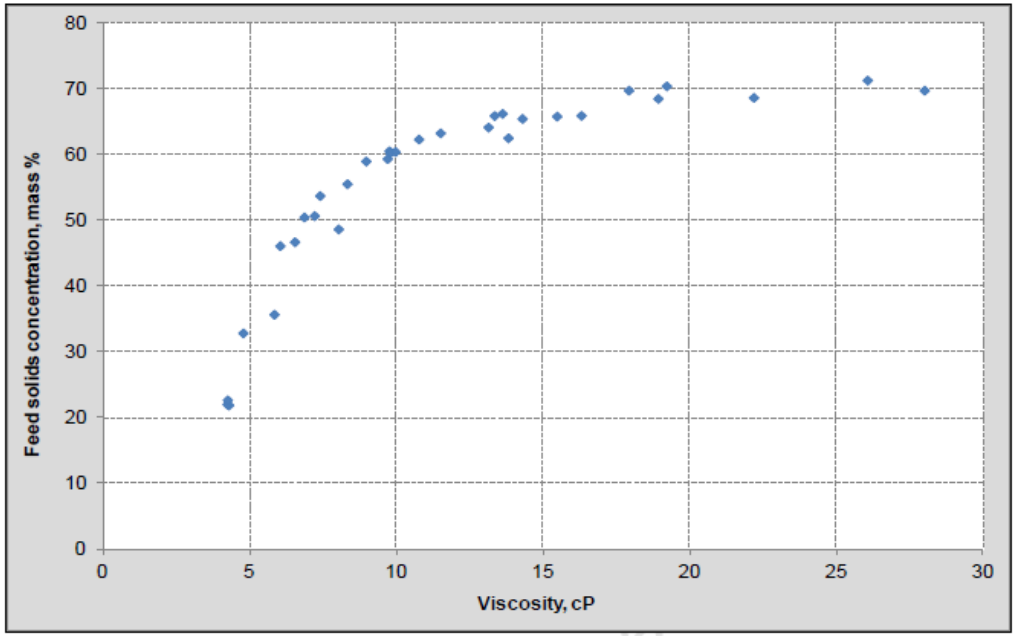
Influence of Viscosity on Classification

Taking these graphs on face value and assuming a transition in viscosity occurs around say 30% v/v then …

For silica ores at around s.g. 2.65 this calculates to be 53 % w/w solids. This is for a limited particle size range of -75 + 50 micron and for pure minerals

Perhaps based on information like this 50-55% could be considered a maximum density from a viscosity perspective for cyclone feed density ??

However for a constant volume fraction as particle size decreases the number of particles in suspension increases which leads to increased particle-particle interaction which leads to increased viscosity



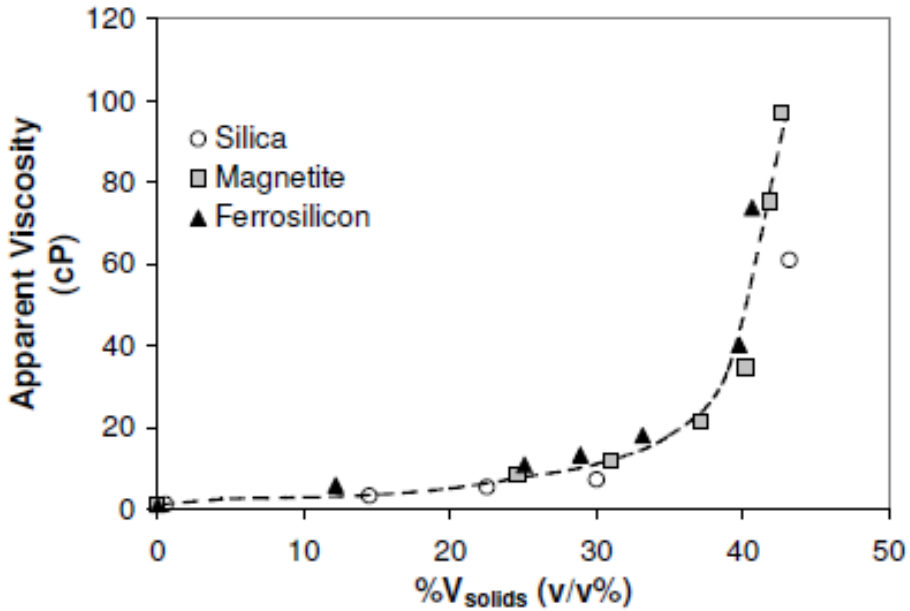


Figure 2.5. The influence of solids concentration on the apparent viscosity of the pulp. Particle size range: -75+50µm. (Aplan, 1985)

The real world of slurries within our milling and classification circuits is slightly more complicated.

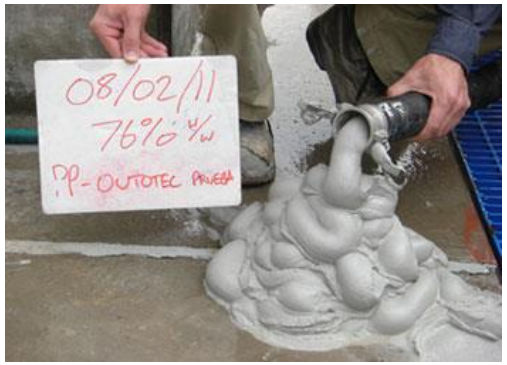
Some of it caused by mother nature and some of it our own making …

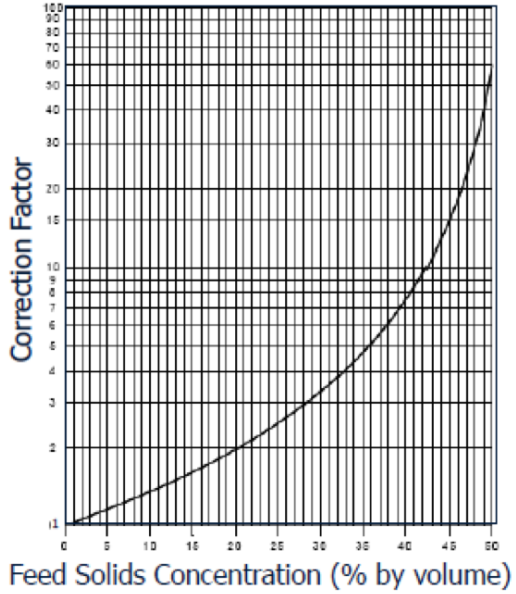
Viscosity of slurries and the potential impact in a cyclone is complicated but may be a function of the following parameters ….

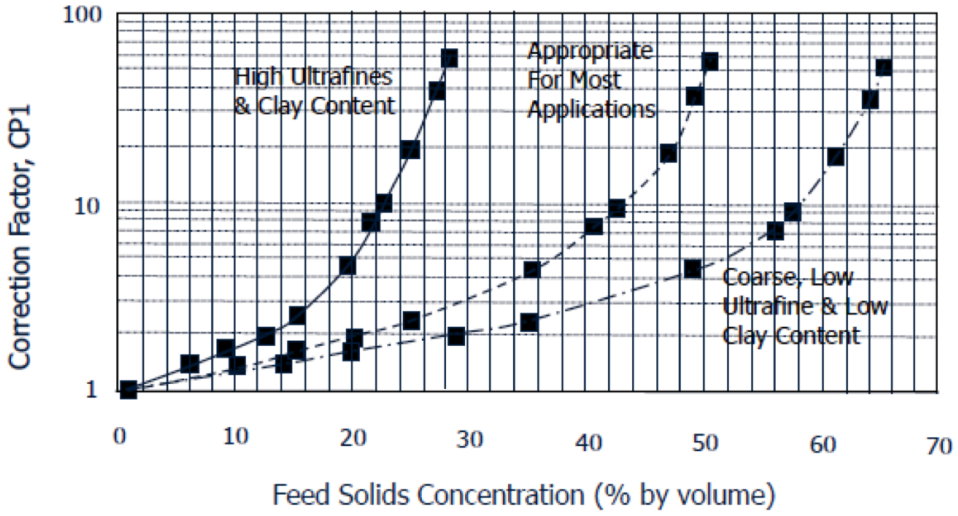
- Particle shape
- Newtonian vs non-newtonian at the applied shear rate
- Nature of particle to particle interaction – potential flocing (minor issue in cyclones perhaps due to high shear?)
- pH and other carrier fluid properties and interaction with particles especially fine (increased binding of water molecules?)
- Presence of clays (with strong surface properties) and interaction with carrier fluid

Once particles are small enough to remain in suspension they contribute to viscosity in some way …

Hydrocyclone designers try to allow for effects of solids concentration and viscosity ……







$$d_{50(c)}\ (\text{actual}) = D_{50(c)}\ (\text{base}) \times \pi_1^{m}\ CP_m \times \pi_1^{n}\ CD_n$$

Product Particle Size Distribution (PSD) is key – not just p80

(A) PSD= excellent classification e.g. from a screen, what about screw classifiers?

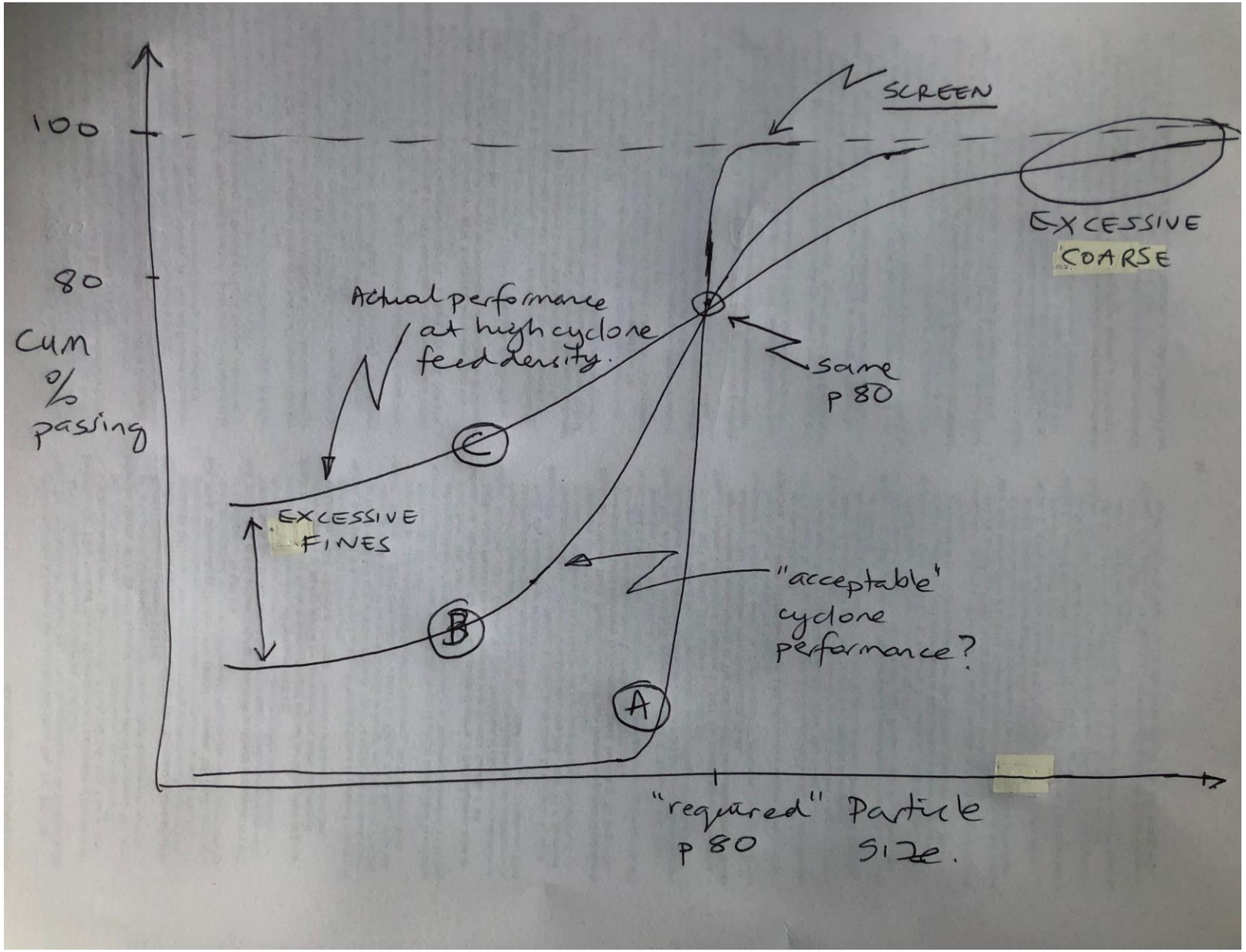
(B) Hydrocyclone generated PSD?

(C) "Flat" PSD commonly generated in high viscosity/high cyclone feed solids concentration

For (C) fines are generated from the milling process – over-grinding in addition to natural fines

Is over-grinding and recirculation of fines making the cyclone feed viscosity and separation situation worse?

As more fines are generated viscosity increases and we make more fines ….. "a spiral of death by fines"?



How do we end up with flat PSD's?

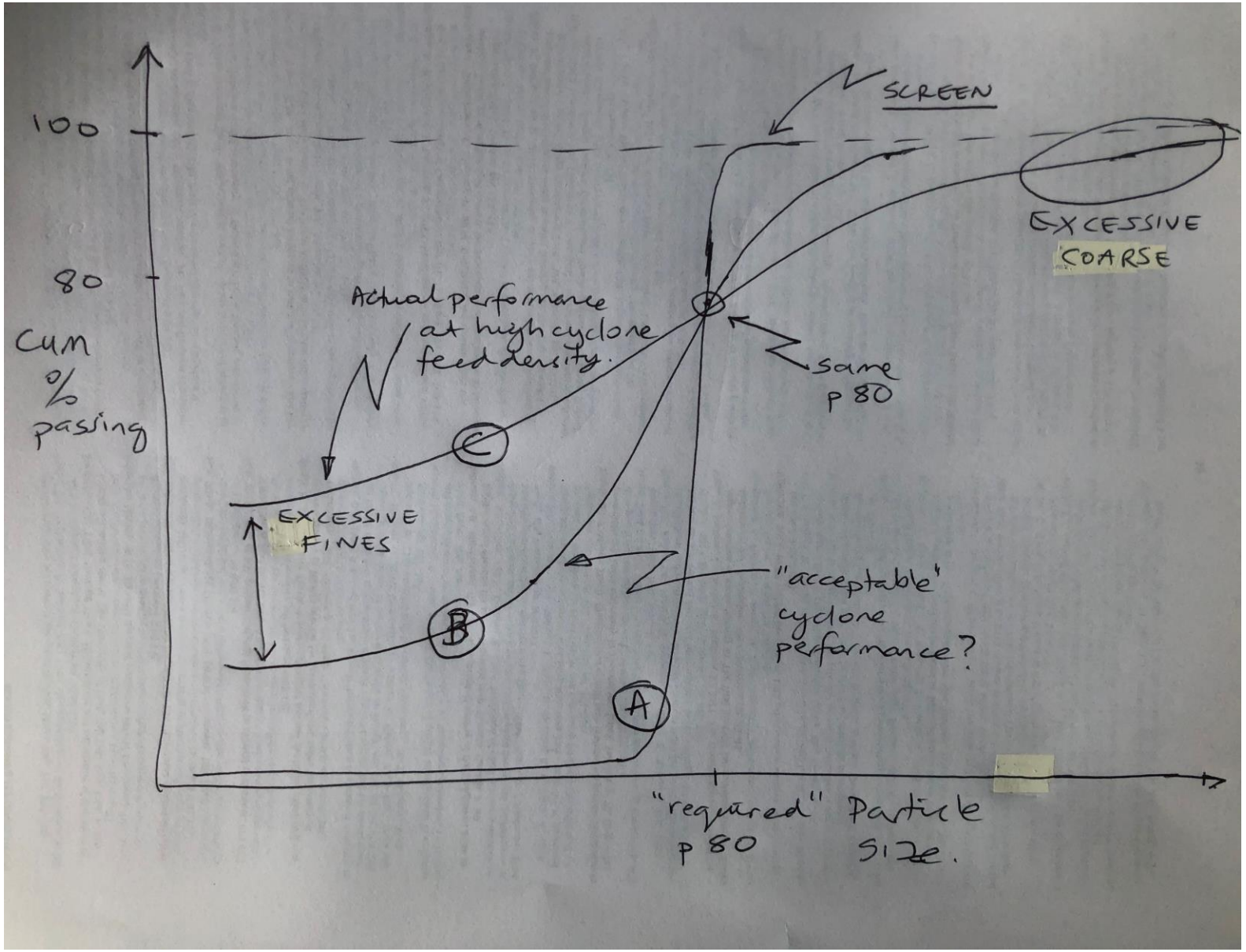
- Often milling circuits are being operated at design solids throughputs well above design

  In this situation cyclone capacity is limited and operators are forced to increase cyclone feed density

- Sometimes water addition piping and pumps cannot supply enough water at higher throughputs
- Often we are forced to produce a high cyclone OF solids concentration e.g. for say 40-50% in a cyanide leach circuit

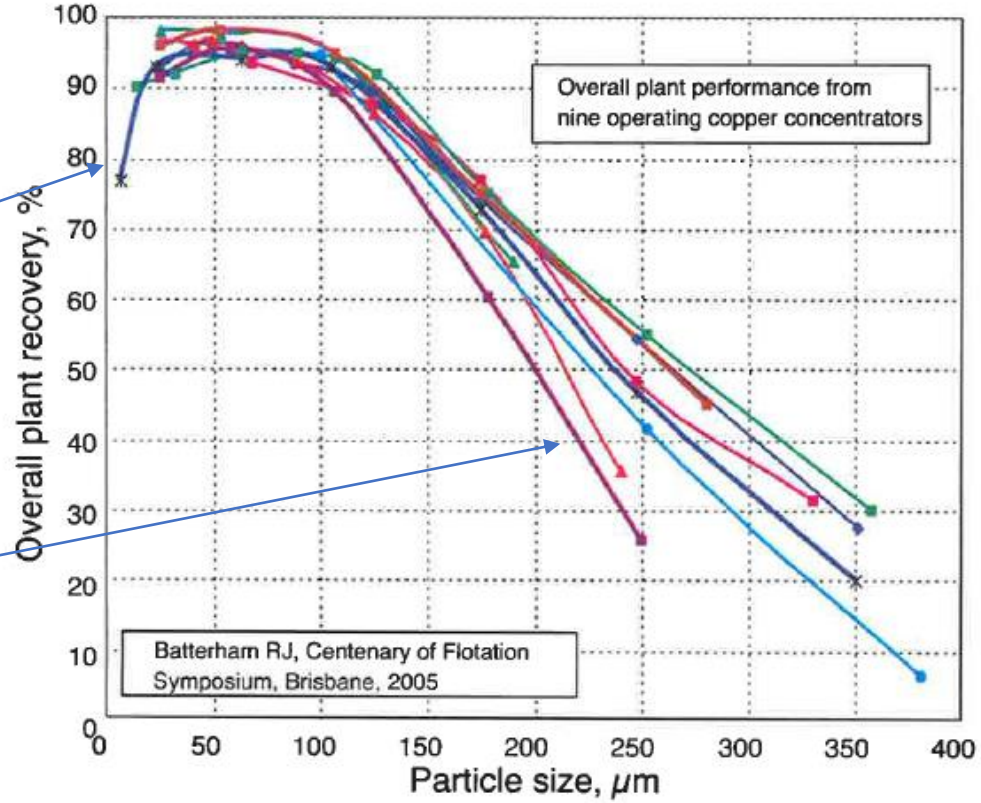
  No cyclone OF thickener to removed and recycle excess water

- Poor design – we designed circuits with high cyclone feed density?



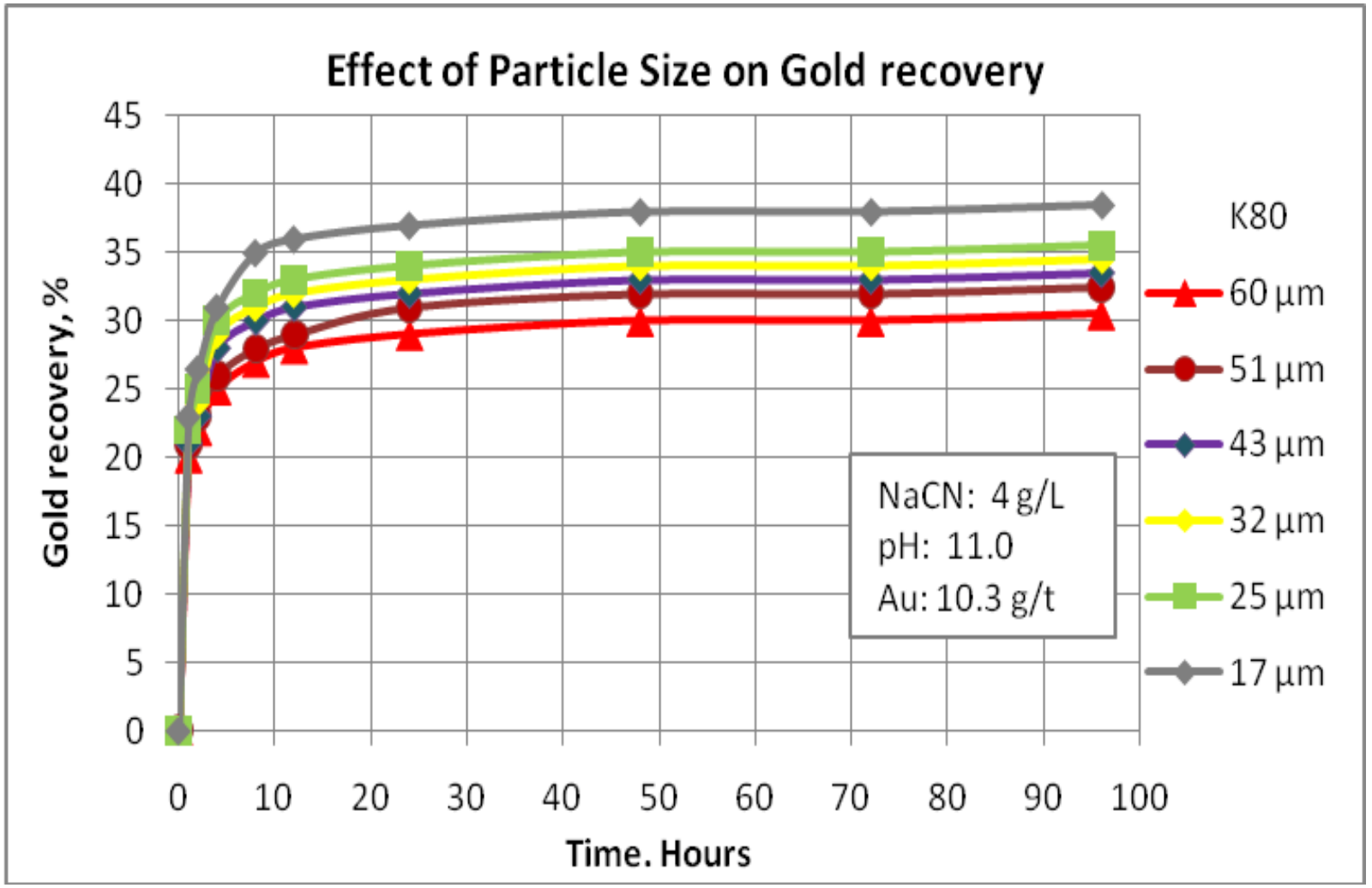
Consequences of a flat PSD – Impact on Flotation Recovery

- Recovery of fines < 10 micron also poor in conventional flotation cells.
- Conventional flotation recovery for particles > 150 micron drops off quickly even for fully liberated particles
- For partly liberated particles the impact is even worse



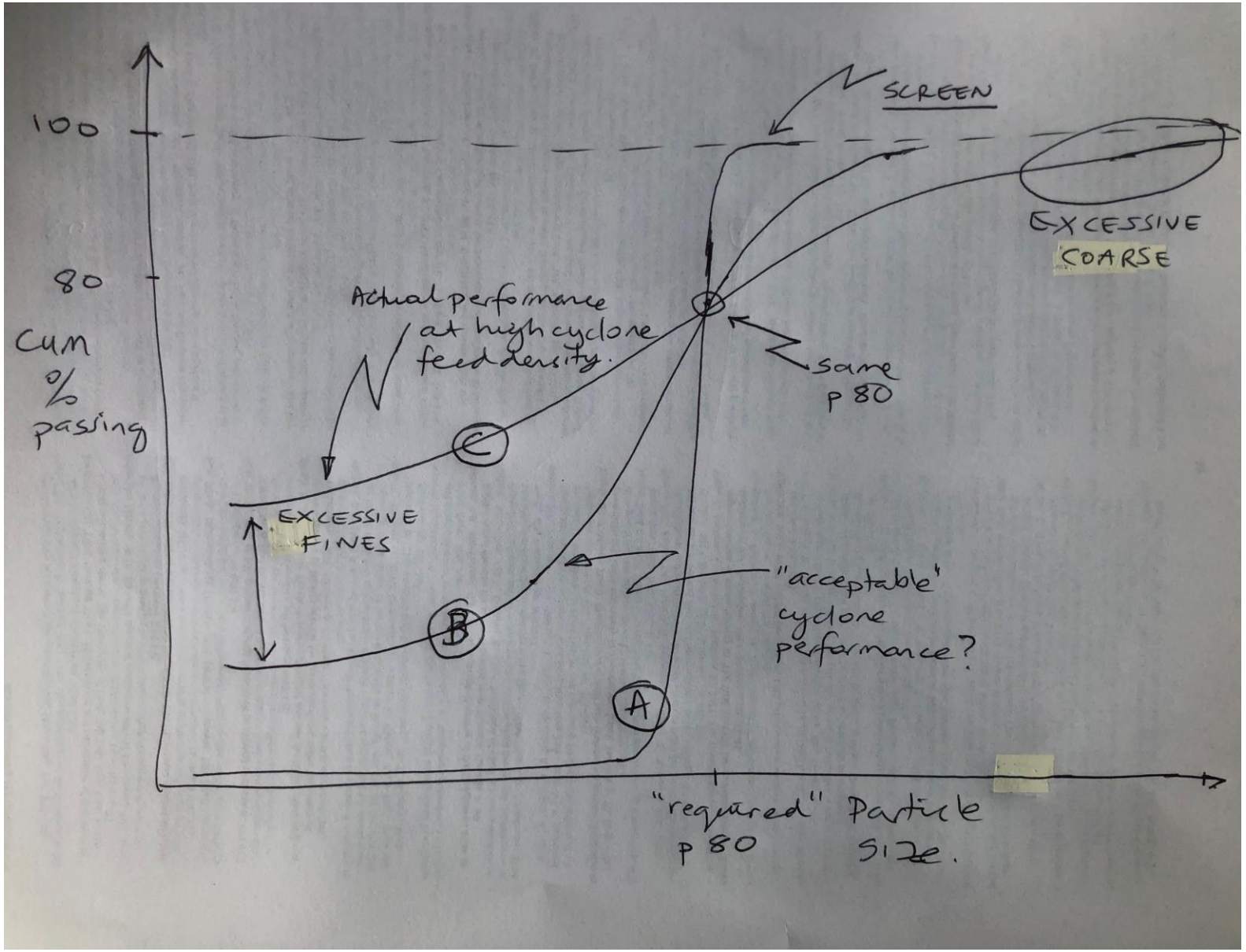
Consequences of a flat PSD – Impact on Cyanide Leach Recovery

- Lower recovery at coarser grind sizes
- Possible increased carbon attrition at increased particle size
- Poor movement of coarse particles and possible sand build-up in tanks.



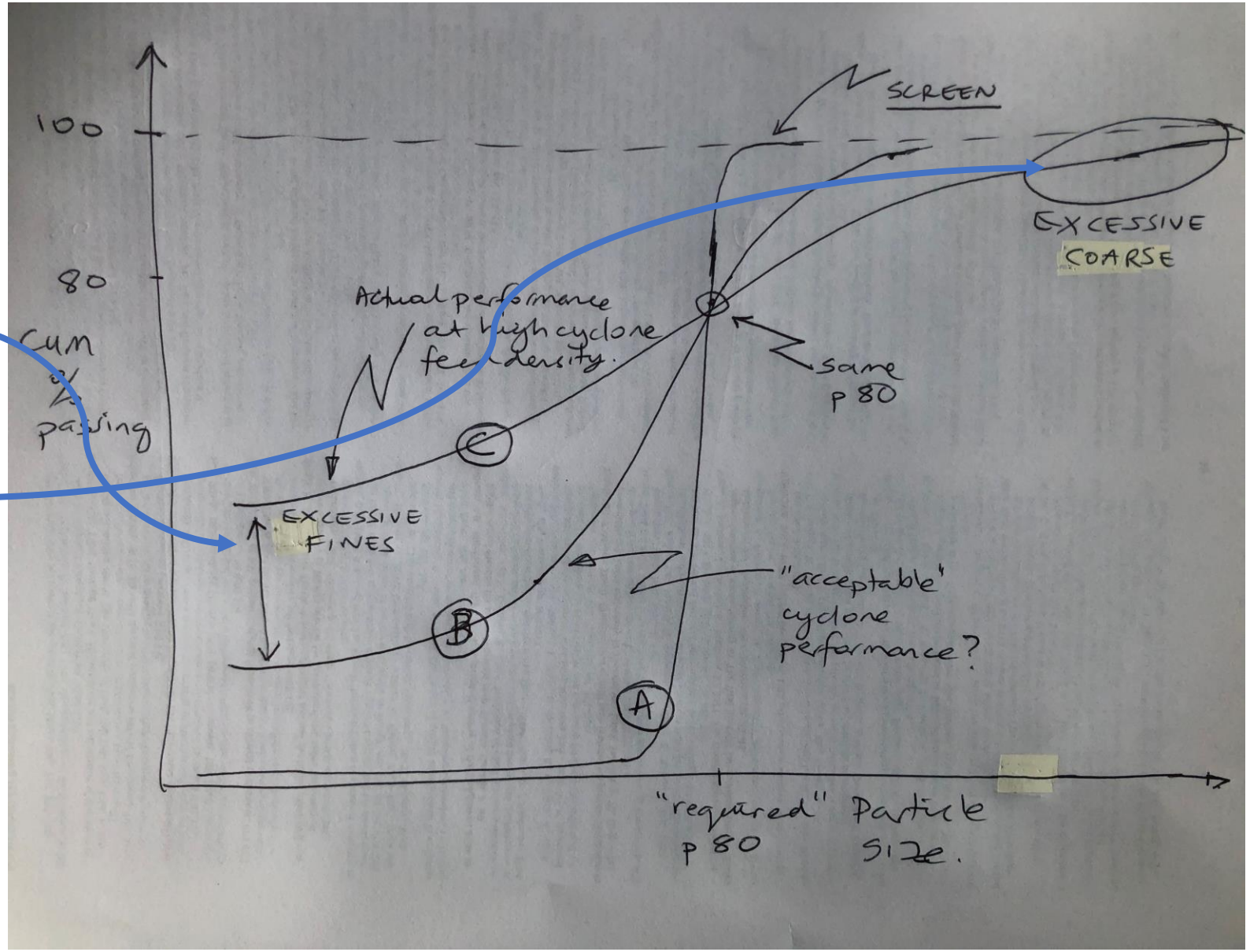
Consequences of a flat PSD – Excessive Ultra-fines in Tailings Dams

- Excessive ultra-fines can make solid liquid separation of solids difficult and more expensive
- Excessive ultra-fines often produces very wet tailings leading to difficult to manage tailings dams with poor water recovery
- Are dams containing excessive ultrafine more prone to risk of failure?



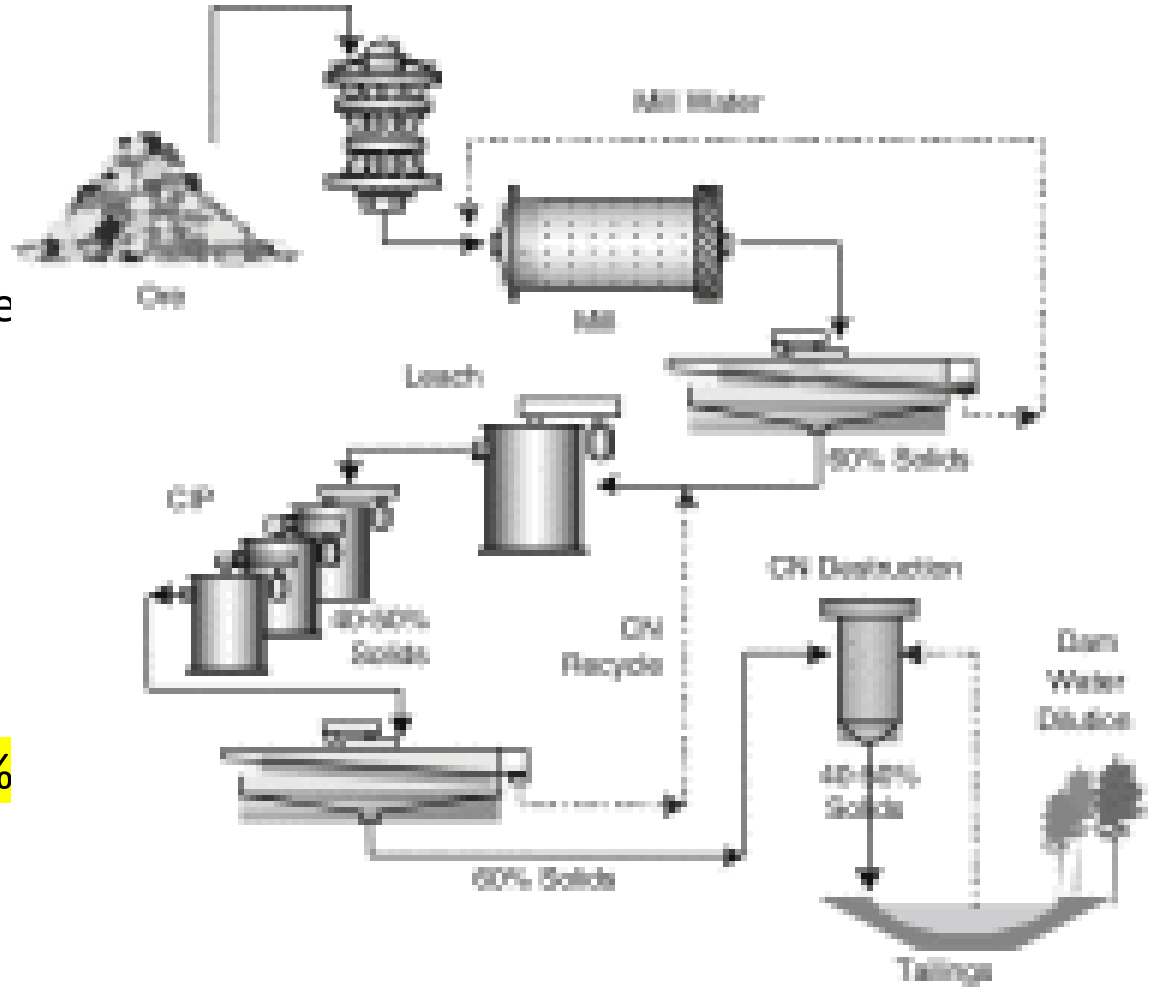
Consequences of a flat PSD – Energy Wastage

- Energy being consumed in over-grinding ores and making excessive fines
- Energy to be re-directed to coarse for an overall superior recovery



Take-away actions ….. ?

- Investigate impact of lower cyclone feed concentration on your PSD and downstream metal recovery
- Plant Trials to increase water addition and reduce cyclone feed solids concentration if possible -
- If possible and recovery impacts are significant consider installing a Leach Feed (or even a Flotation Feed?) Thickener in front of your plant
- Insist of design of milling circuits with say 40-45% w/w solids MAX !!



Target a sharp PSD in your milling circuits. Don't let the design or limitations of your milling circuit dictate your recovery !