

# **THE DESIGN AND BENEFITS OF CONTAINERISED MODULAR PLANT DESIGN**

Andrew Foster

Downer EDI Mineral Technologies Pty LTD, 11 Elysium Road, Carrara, Queensland, AUSTRALIA

## **ABSTRACT**

Modular mineral processing plants have been adopted in various applications for many years. Typically, a modular concept will be adopted in place of the traditional site constructed plant method when: the operating site is very remote, and / or, site access and space is limited, and / or, the project schedule requires plant modules to be built in parallel, and/or, the plant has a short operating life at one site and will then be moved to another site

Containerised plants are modular plants that are further designed to fit into standard sea freight sized modules. This approach can yield great benefits where the plant will be moved frequently from site to site or the shipping cost to site is significant and the processing equipment can be made to fit inside standard container-sized blocks without constraining the operation and maintenance of the plant.

To create the building blocks, either standard sea containers can be suitably modified to accept all the equipment or a fit-for-purpose structure can be designed and built to the same size as standard sea containers complete with standard corner connection blocks.

When designing plants of this nature, effort is required to ensure best possible use of space and this often requires the engineering company to work with the relevant equipment suppliers to make some modifications to vendor equipment to allow the best layout to be achieved within the available space.

This paper presents in more detail the above concepts, as well as a case study of recently designed, constructed and now operating containerised Kelsey Centrifugal Jig plants.

## **INTRODUCTION**

Typically, a modular approach is followed where special circumstances make it more efficient from a project cost and schedule point of view. It is also important to look beyond the initial design, construction and commissioning parts of the project as there are also other factors regarding the nature of the operation and overall project lifecycle that can make a modular approach even more attractive.

Naturally, a modular plant can only be considered for plants (or parts of a plant) where the size of the process equipment involved allows assembly into appropriately sized modules to be conducted. Plants (or sections of a plant) comprising very large equipment, e.g. large capacity run of mine tips, large crushers, large mills, tanks, thickeners, large bins, etc., are clearly not good candidates for a modular plant approach. Some typical examples of project criteria that could make a modular approach attractive include:

- Very remote sites
- Short operating life
- Multiple mine sites each with relatively short life span
- Relatively small process equipment
- Site trial / pilot plants
- Sampling plants
- Fast track project schedules, requiring parallel off-site completion prior to assembly into plant on-site
- Phased increase in production capacity.

Some applications that have successfully adopted a modular approach include:

- Spiral concentrator plants
- Dense Media Separation (DMS) plants (both diamond and coal plants)
- Diamond final recovery plants
- Gold leaching plants
- Jigging plants
- Coal washing plants
- Cement and aggregate plants

The decision of modular or a traditional “all onsite construct plant” would typically be made during the pre-feasibility stage of a project. The evaluation process would include some initial conceptual designs and costing to determine if there are cost and schedule benefits to either option. A key step in this conceptual design stage would be to determine what size modules would need to be used to house all the processing equipment and ancillary systems, while still allowing sufficient operating and maintenance space in the plant. It follows that, in order to make operation and maintenance easier, more than less space would be asked for by future operators of the plant. However this drives up the cost to construct the plant due to additional steel and higher transport costs for shipping to site. Against this will be a trade off by the project team pushing for less space in order to reduce project costs and shorten the project schedule.

In special cases where the equipment sizes allow, consideration can be given to designing the modules to the size of standard shipping containers in order to reduce shipping costs as much as possible. This is particularly attractive for plants that require frequent moving from one location to another or transport into difficult to access areas. Designing a compact yet easy to operate / maintain plant around

shipping container-sized modules requires “out of the box” innovative thinking during the design process (from flow sheet to plant layout).

This paper firstly reviews the basis for selecting a modular approach and then focuses on designing modular plants based on container sized modules. Finally a case study is presented on the design, construction and operation of containerised plants.

### **THE MODULAR VERSUS TRADITIONAL PLANT DECISION**

This section presents some key factors that should be considered at the start of a new process plant project which may result in a modular approach yielding some significant cost and schedule benefits to a project.

#### **Plant equipment size – is a modular plant really feasible?**

This is the first question that needs to be answered. Once the process flow sheet has been defined and basic equipment selection conducted, it is possible to determine if a modular plant approach might be feasible. The size of modules that the equipment has to fit into is generally determined by the constraints imposed by the method of transport to site as well as on-site lifting facilities (e.g. available cranes). The transport to site will invariably have road haulage as part of the journey and in some cases will also include sea freight and perhaps rail freight. Each mode of transport has its own shipping cost verses load size relationship as well as absolute size constraints determined by the relevant rules, codes and conventions. This paper focuses on both road and sea freight constraints (as these are the most likely modes of transport) and on module sizes that can be accommodated by conventional transport / shipping methods. Extra large modules, such as those involved in the offshore oil and gas industry that typically require specialist vehicles, vessels and crane barges, are excluded from the scope of this paper.

**Road freight** has width, height and length constraints. Although standard vehicle widths should be within 2.5m, in most western countries loads up to 3m wide can be transported without escorts. Wider loads, typically up to 5.5m, can be transported with suitable extra wide load escorts, while loads above 5.5m widths and up to 8m can also be road hauled, but at considerable cost due to the requirement for special transport carriers (multi-wheeled trailers) and large capacity cranes. In addition, special arrangements need to be made with state and local authorities which adds to the complexity and costs involved. From a height perspective, in most western countries a maximum height of 4.3m above ground is stipulated to clear bridges and overhead cables although the European Union limits total load heights to 4.0m. Based on a typical trailer height of 1.2m above the ground, this 4.3m total height gives a 3.1m maximum allowable module height. Load length is restricted to 14.6m in most western countries (semi trailer) with some restricting to 13.6m (Europe). It must be stressed that these maximum load dimensions are not specific for any one area – they are presented for indicative purposes. Maximum allowable load size will depend on which country the load is being road hauled and in most cases will also vary from state to state within that country.

**Sea freight** (like road freight) has dimension constraints linked to cost. The cheapest form of shipping is via a registered container. A registered container is a load carrying box or frame that is built to ISO Standards that has been approved and issued with a Container Safety Certificate for travel by road, rail or ship. This is discussed in detail in a later section. Loads larger than containers are shipped as “break bulk” where dimensions are relatively un-restricted however costs are orders of magnitude higher than shipping via registered container.

For general comparative purposes, escorted road freight (>3m and <5.5m wide loads) will cost double that of unescorted freight (<3m wide loads). Break-bulk sea freight will usually cost a factor of three (3) times as much as container freight for the same volume shipped.

It follows that a sensitivity analysis needs to be considered on transport costs versus overall project costs in conjunction with the size of module required to ensure good operability and maintainability in the design. The common perception is that modular plants are less easy to operate and maintain due to their inherent compact nature. This is not necessarily the case and if proper thought and planning is given during the layout stage of the design, a modular plant should not constrain good plant operation and maintenance. In fact, a modular design approach will invariably lead to a more compact design. This has a positive benefit for the project in that costs will be reduced during the design phase as the focus of the design team will be producing a compact and space efficient design. Many traditional plants have excessive / more than required space and so are not necessarily the most efficient designs. In order to use space efficiently in the design of a modular plant, it is critical that the design team adopt a different approach to conventional plant layouts. Some examples of innovation during the layout stage are presented later in this paper.

#### **Site conditions and site works.**

The key consideration under this section is cost of site works. There will always be a site works component to every new plant project, however this can be significantly reduced (and in some special cases almost eliminated) by choosing a modular plant approach. The higher the cost to conduct work on site, the more attractive a modular approach will be. A trade off study needs to be conducted as part of the decision process. Some factors that drive site works costs include:

- Site location - the more remote the site, the higher the costs involved for many obvious reasons, e.g. transport and logistics costs, availability or choice of contractors and site labour hire firms, travel and accommodation costs, location of site with respect to prevailing construction costs in that area / country
- Available space onsite - in some cases, space is limited making off site construction of the plant in modules followed by a “just in time” approach to delivery and assembly onsite an attractive option
- Construction, assembly and commissioning costs - it is well known that the cost to perform site works will usually be significantly higher than conducting the same work in a workshop environment. This increase in cost can range from a factor of two in the case of a relatively non remote site up to several times higher where very remote sites are involved.
- Skills level and quality of available site works contractors - bringing in highly skilled people to perform critical work on a project with a remote location will significantly drive up project costs
- Environmental considerations - it follows that risk to environment is higher onsite than in an established workshop where environmental controls are well established. Depending on the location of the site, this could yield advantages to projects where construction in an environmentally sensitive area is required. By reducing the amount of site works by pre-building and assembling the plant in modules in a workshop the environmental risk can be lowered

**Life of plant and/or mine issues.** For cases where the life of plant / mine is relatively short or a mine comprises several deposits, a modular plant could yield the following attractive benefits:

- Reusing / selling entire plant

- Where the required life of the plant is relatively short, a modular plant could be dismantled and sold or reused on another site in its entirety
- Consider the obvious economic benefits of this approach versus the traditional plant where typically only process equipment (pumps, screens, crushers, etc.) are removed and sold via used equipment dealers
- Multiple operations
  - For projects where the mine plan involves multiple smaller operations, a relocatable modular plant could be an attractive option worthy of consideration
  - There are many examples of where this applies including coal, diamonds, stone and aggregate, etc.
- Reclamation and reprocessing of old tailings dumps
  - These operations typically consist of short duration operations (from several months to a few years) at each dump site before being moved onto the next dump, so they are a good example of where modular plants would have obvious advantages
- Pilot or site trial plants
  - These plants are often used for testing or demonstrating a process or items of equipment for a new project or client and are obvious candidates for modular design as they are only needed at each site for a short duration before relocation to other sites.
  - Where plants are to be trialled at multiple sites consideration should be given to containerization to reduce shipping costs (this is discussed in detail later in this paper)

#### **Other factors.**

Several other factors should be considered as they may yield benefits if a modular approach is adopted. They include:

- Project schedule advantages
  - Time savings can be made by making modules in parallel at different locations / constructors' facilities and then assembling onsite in a planned order
  - This is typical of offshore oil and gas projects where the entire plant or platform is constructed in modules at various sites in parallel and shipped to the final assembly port/site in the required sequence
- Direct cost benefits
  - Modules can be constructed, assembled and tested in countries where fabrication and general labour costs are the most attractive
  - In order for this benefit to be maximized, both construction costs and shipping costs need to be minimized
  - Sea and road freight will obviously be involved with this approach, so by designing the modules in container-sized units, the modules can be shipped as in gauge "break bulk" units, which attracts a lower sea freight cost than out of gauge freight, as well as making road freight very easy

#### **CONTAINERIZATION – BEYOND THE TRADITIONAL MODULAR PLANT**

In special cases the benefits of plant modularization can be maximized by containerizing the plant modules. These cases would be where the shipping costs constitute a large portion of the overall costs over the life cycle of the plant. This approach seeks to minimize shipping costs and maximize ease of handling and site assembly, while maintaining good plant operability and maintainability.

#### **Applications and project criteria for which container modules provide real advantages – unlocking the potential**

The key advantages of containerised modules are:

- Minimizing shipping costs to the lowest possible – there is no cheaper form of road and sea freight than shipping containers
- Ease of handling onsite – faster and lower cost site works. It follows that handling container sized modules is easier than larger modules that would require larger vehicles and bigger cranes etc.
- A containerised plant will by its very nature be a compact plant with just enough space for operation and maintenance. This has advantages in ensuring that the design focuses on maximizing space utilisation and minimizing equipment both of which are key drivers in lowering project costs. It is unlikely that excessive space and associated unnecessary costs will result from a containerised design.
- Schedule benefits due to possible reductions in shipping time.

Against the background of these above advantages the following are examples of where containerised modular plants have previously been adopted:

#### **Site trial or pilot plants.**

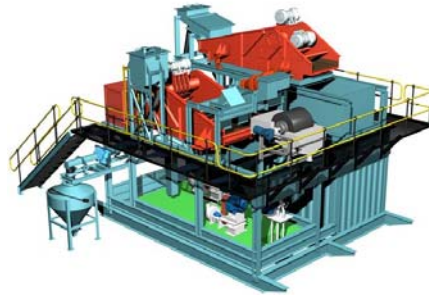
- These are plants that are shipped to many locations for site trials and so minimizing shipping costs is important
- Furthermore, quick set up and commissioning time on-site is important to maximize utilization of capital equipment
- Maximum time can be spent on-site proving up equipment, rather than shipping and assembling the plant
- Some examples include:



**Figure 1 – Kelsey Centrifugal Jig Pilot Plant**



**Figure 2 - Spiral Concentrator Pilot Plants**



**Figure 3 - Dense Media Separation Plants (courtesy ADP Projects)**

**Relocatable short life cycle / multi-site plants**

- As the name implies these applications would be where the plant is required to process material for a relatively short period of time before moving onto the next site
- Some examples include: tailings dump retreatment, sampling plants and toll treatment applications



**Figure 4 - Charter vessel based marine diamond sampling containerised plant (Courtesy BDM)**



**Figure 5 – Kelsey Centrifugal Jig Relocatable Plant for recovery of zircon from tailings dumps**

**The building blocks - standard container dimensions**

Table 1 below shows the standard container dimensions in accordance with ISO Standards and the International Convention for Safe Containers which governs all sea freight container standards

**Table 1 – Standard Shipping Container Dimensions**

Container Type	Length	Width	Height	Max Mass
10 Foot Half GP	3.0m	2.438m	2.591m	12 tons
10 Foot Half GP – high cube	3.0m	2.438m	2.850m	12 tons
20 Foot GP	6.058m	2.438m	2.591m	24 tons
40 Foot GP	12.192m	2.438m	2.591m	30 tons
20 Foot High Cube	6.058m	2.438m	2.850m	24 tons
40 Foot High Cube	12.192m	2.438m	2.850m	30 tons

The dimensions and maximum allowable masses in Table 1 represent the plant module size options available to the containerised plant designer. In order to minimize freight costs it is necessary to either use certified containers or container structures that have been certified and thus carry a Safety Approval Plate or CSC (Container Safety certificate) in accordance with the International Convention for Safe Containers. If a container does not carry a valid Safety Approval Plate or CSC then it will be shipped as “break bulk” at significantly higher costs. A separate section is dedicated to this subject later in this paper. Several options of module construction are available to the designer. These include:

- Utilizing standard containers and suitably modifying them
- Building the plant on top of a standard container flat rack or bolster platform
- Building new “container” structures to the dimensions above

The advantage of **modifying a standard container** is that the certification can be retained provided the modifications are approved by the original container designer / manufacturer. Designing modules using standard containers does have limitations as it is difficult to spread large concentrated loads typical of heavy equipment within the existing container structure. The plate thicknesses of standard containers is thin (typically 3-5mm) which makes structural engineering of additional point loads difficult. However, this said, if the load can be spread on a frame which is joined to the container over a large area then it can be done. In some instances where protection from the elements is required, using a fully clad container can offer a good solution. Due to structural constraints, modifications are restricted to cutting limited size access holes through the side walls, roof and deck. The added access openings cannot be placed close together or near the ends of the container structure. Typical examples where containers are used include: electrical switch rooms, control rooms, laboratories, x-ray sorting plants and other plants where smaller lightweight equipment is used – typically 1000kg or less per item.

Building a **plant module on top of a certified bolster or flat rack** is more flexible, as a purpose-designed structure can be built on top of the bolster or flat rack structure to house heavier equipment without jeopardising container certification. In order to stack modules on top of each other, a frame suitably designed to the correct size and dimensions can be attached to the flat rack / bolster. This frame would be used for stacking of modules onsite only – not shipping, otherwise the structure will require certification. With this method the original certification is maintained and a very substantial structure can be achieved that can house very heavy equipment. Unfortunately the structure of the flat rack / bolster cannot be changed without approval from the original designer and manufacturer and so this can cause some significant constraints for plants that require significant openings through the floor between modules for pipes and chute work.

Building an appropriately sized **purpose-built container module structure** equipped with twist lock corner connector blocks gives the most flexibility and allows the plant designer to fully optimize the plant design and layout without any constraints other than the physical size of the module.

The main drawback of using a purpose designed structure is that certification will need to be obtained to allow a Safety Approval Plate to be carried in accordance with the International Convention for Safe Containers.

#### Container certification – minimizing shipping costs.

The International Conventions for Safe Containers was signed by members of the UN in 1972 to ensure the safety of all people involved with handling containers. This convention applies to all new and used containers used for international transportation. This convention defines all the design, construction, operation, security, inspection and control aspects of shipping containers.

To obtain certification for a new container module a Marine Classification Society needs to be engaged. Classification societies that certify new containers include: American Bureau of Shipping (ABS), Bureau Veritas (BV) and Germanischer Lloyd (GL).

The **Container Certification Procedure** encompasses:

- *A Review of all detailed design drawings* for the containerised module structure to verify that it complies with the requirements of the respective Classification Society, International CSC rules, and all other relevant codes and standards
- *A prototype structure is built and subjected to load tests* which are witnessed by the Classification Societies’ surveyor. Tests under load include: lifting, stacking, concentrated loads, transverse racking, longitudinal restraint, end walls and side walls. This would typically be done at an established and approved container manufacturer –there are many of these in China and other South East Asian countries.
- *A survey of the container module manufacturer* is conducted as well as follow-up visits during manufacture. This survey is primarily focussed on manufacturing quality control procedures and specification with special reference to welding procedures and specifications.
- *Issue a certificate* attesting to the container modules compliance with the specified codes, regulations and standards as well as structural fitness for the specified service or use

The cost for the above process would typically be USD 20,000. Some containerised plant designers and builders have opted to have a standard module frame(s) fully certified and then use this certified frame as a basic building block during all further container plant designs, rather than having to certify every new design.

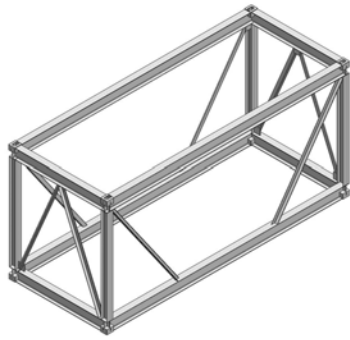
#### Design Considerations

Some key design considerations are discussed in this section plus some innovation used to “create space” within compact modules.

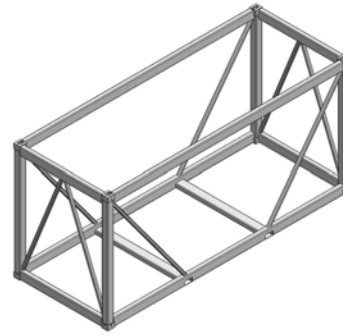
**Structure** – the structure needs to be capable of withstanding the loads imposed during operation as well as shipping / transportation loads. The container module frame construction is generally based on either conventional structural steel or square / rectangular hollow section members. Table 2 shows typical members used and is illustrated in Figures 6 and 7.

**Table 2 – Typical Container Structural Member Sizes**

Module Member	Conventional sections	Hollow sections
Columns	152 x 152 x 30 UC	150 x 150 x 6 SHS
Beams	252 x 146 x 31 UB	200 x 100 x 6 RHS



**Figure 6 - Conventional structural members**



**Figure 7 - Rectangular and square hollow sections**

Transport and handling loads are accommodated by designing for the required certification load tests. These load conditions are summarised below. The total mass of the container module plus rated load (gross mass) is defined as R, payload as P and g is gravitational acceleration:

- Static lift from all four corners when loaded to  $2 \times R$
- Lifting from one end (two adjacent bottom corners) up to an angle of 45 degrees for the 20' container module and to an angle of 30 degrees for the 40' container module when loaded to  $2 \times R$
- Container module bases capable of withstanding a longitudinal tensile and compressive load of  $2 \times R \times g$
- End walls / structure capable of withstanding a load of  $0.4 \times P \times g$
- Side walls / structure capable of withstanding a load of  $0.6 \times P \times g$

Structural steel mass will typically be around 2.5t per 20' module. One aspect that requires consideration is the connections between the container modules. Standard container twist lock connectors are designed for transport however they do not give a secure connection required for mineral process plants. It is necessary to design in bolted connection pads adjacent to the corner connectors for securing to the foundations (typically a concrete slab) and between the modules themselves.

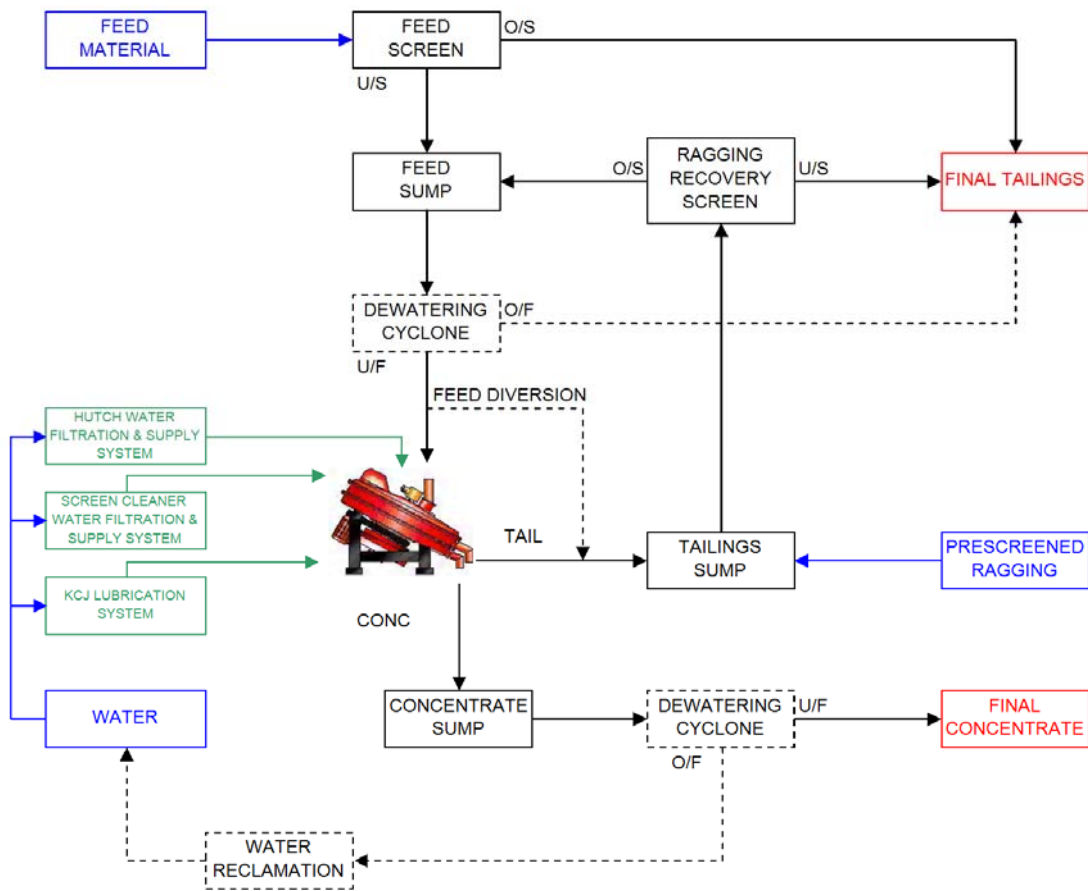
**Process equipment** has the biggest impact on arriving at a space efficient design. In order to maximize space efficiency it is common that an iterative approach is applied between finalizing the flow sheet and equipment selection. To put things into perspective some suggested maximum equipment sizes are given below:

- Pumps – although cases of putting 20/20 dredge pumps in 20' container modules are known, generally pumps up to 10/8 size (and perhaps 12/10) will quite easily fit into container modules and still have sufficient space for maintenance and operations
- Vibrating Screens require careful consideration of the support structure and integrating this with the container module structure. Placing single and double deck screens onto the module with support fittings in the main structural members (with columns underneath) is a good solution. Typically single and double deck screens up to 1.8m wide by 4.2m long can be accommodated on container modules. Multi-deck screens such as the Derrick® Stack Sizer™ can be fitted within the module up to a maximum of 5 decks (more on this later)
- Kelsey Centrifugal Jigs – J1300 model fits within a container module
- Magnetic drum separators typically up to 1.8m wide will fit transversely within a container module

Other equipment such as pipe work, chutes, bins, sumps and electrical cabling systems can all be designed into the container modules, however consideration needs to be given to inter-module connections. Pipe work can be flanged at appropriate positions. Electrical cabling is either temporarily installed for workshop commissioning (and then removed and permanently installed onsite), or plug and socket arrangements are used for pilot / site trial plants. Several innovative design features are highlighted in the Case Study presented in the next section.

**CASE STUDIES – CONTAINER MODULE KELSEY JIG PLANTS**

Downer EDI – Mineral Technologies has designed and built a number of Kelsey Centrifugal Jig (KCJ) plants based on container-sized modules. KCJs are typically used in applications where fine heavy minerals (down to approximately 6 micron) are required to be separated from gangue material and/or where the specific gravity differential between heavy and gangue minerals is relatively low, such that conventional gravity separation techniques are unable to achieve target separations. Typical feed sizes to a KCJ will vary from -500 micron to -150 micron with -10 micron slimes generally removed prior to processing. Typical applications for a KCJ include processing of mineral sands, gold sulphides, tungsten, tin, tantalum, iron ore, chromite, etc. A typical KCJ circuit is shown in Figure 8.



**Figure 8 – Typical Kelsey Jig plant flow sheet**

Two such KCJ plants based on container-sized modules are discussed in these case studies. One plant was based on the smaller Model J1300 KCJ unit (built and used as a permanently installed plant for a customer in Australia) and the other based on the larger Model J1800 KCJ unit (designed as a relocatable site trial plant). These two plants had to be designed so that they could be effectively used as pilot or demonstration plants. Key design criteria included:

- Minimize shipping costs
- Minimize set up and commissioning time
- Maximise ability to transport into very remote locations and set up and commission without the need for any local engineering support or infrastructure

For these reasons a container module plant was selected. The two plants are shown in Figures 9 and 10



**Figure 9 –Model J1300 KCJ Pilot Plant**



**Figure 10 – Model J1800 KCJ Pilot Plant**

### Model J1300 KCJ Modular Plant Design

The design premise was to fit this plant into two 20' container modules to keep shipping costs to a minimum and use a “plug and play” philosophy where possible. The major equipment included:

- Model J1300 KCJ unit (6 tons)
- 3-deck Derrick® Stack Sizer™ screen (1.5tons)
- Jig feed pump (Warman 3/2) and sump (0.8t)
- Jig tails and concentrate sumps and pumps (0.4t)
- Final tailings sump and pump (Warman 4/3) (1.0t)

Plant design throughput was 16 t/h solids.

A container module was purpose designed for the lower module as this housed the KCJ unit which imposes significant dynamic loads (up to 10 kN at 200rpm 900mm above footings) onto its support structure. A modified side opening standard freight container was used for the top module – see Figure 11. This container was utilized because it already had certification in place, while offering a cover over the screen, a substantial base structure and side opening doors. Modifications to the floor to allow the screen chutework to be fitted were conducted in conjunction with the container designer Royal Wolf to retain certification. The intention was to certify the bottom purpose-designed container module structure, however this did not materialize as this design was used to fulfil an urgent client order and so certification was never completed (although structural design had been conducted to cater for both the operational loads and the certification load tests envisaged).



Figure 11 – Standard side open container – LH side and end fitted with doors.

Due to the dynamic load constraints the jig was located in this lower module to keep the design as efficient as possible from a structural point of view. In order for the Jig to be positioned low down the concentrate and tailings sumps and pumps that the KCJ unit discharges into had to be as compact as possible. Jet pump hoppers (jet pump combined with sump bottom) were used as they can operate either flooded or with air in the suction thereby requiring no sump residence capacity, and because they are more compact than centrifugal pumps, allowing the sump bottom to be lowered to the floor – see Figures 12 and 13.



Figure 12 – Kelsey jig concentrate and tails jet pump hoppers

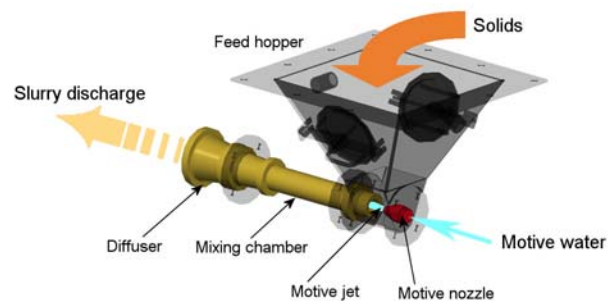


Figure 13 – Jet Pump basics

The Derrick® Stack Sizer™ screen was selected due to its superior performance on fine minerals combined with the layout of the Stack Sizer™ unit, where the multiple screen decks are stacked on top of each other, thereby saving significant space. An added advantage for KCJ modular plants is that selected decks can be used to perform both the feed and ragging recovery duties within one unit.

The electrical control room was designed to fit within a standard “mini-cube” insulated and air-conditioned container located nearby by the main plant.

As part of ensuring the KCJ unit could be accessed during major maintenance activities, it was mounted on two slides. The sliding elements were made from four Vesconite™ pads attached to the KCJ frame running on stainless steel rails (6mm 316 stainless) attached to the tops of the beams. This is shown in Figure 14 below.





**Figure 14 – KCJ unit maintenance slides – jig in maintenance position.**

Also visible in Figure 14 are the cantilevered walkways attached to the base of the top container module. Note that no knee bracing is used, as each profiled support bracket which forms part of the walkway is bolted onto the top module prior to being lifted on top of the KCJ module, thereby making site assembly safe as no working at heights is involved. This plant was fully assembled and commissioned on water prior to being shipped to the customer's site.

### **Model J1800 KCJ Modular Plant Design**

The Model J1800 KCJ modular plant has significantly higher design capacities (up to 50 t/h solids) than the smaller Model J1300 KCJ plant and so requires significantly larger supporting equipment. The design premise for this plant was to fit the plant into four 20' container modules again to keep shipping costs to a minimum and use a "plug and play" philosophy where possible. Major equipment included:

- Model J1800 KCJ unit (15 tons)
- 4-deck Derrick® Stack Sizer™ screen (2.1tons)
- Plant feed bin – jet pump delivery
- Jig feed pump (Warman 4/3) and sump (1.2t)
- Jig tails and concentrate sumps and pumps (Warman 4/3 and 2/1.5) (1.5t)
- Final tailings sump and pump (Warman 6/4) (1.5t)
- Water tank
- Floor spillage sump and pump
- Compressor
- MCC and PLC room.

The plant modules were a combination of modified 20' shipping containers and purpose built container frames. The purpose built container modules were again designed to comply with the certification test loads that the structure would be subjected to. Due to the schedule of a key site trial being moved forward, time did not allow certification to be finalized prior to shipping to the first test site.

**Design innovations** used with this plant to create a container module plant that has sufficient operating and maintenance space included:

- Elimination of bracing by designing sumps and bins as part of the container module structure (plate work within the structural members and suspending sumps from the top beam of the container module), thereby making equipment much easier to access (see Figure 15)
- Significantly reducing site civil works by designing an integral floor spillage sump into the floor of the bottom container module, such that only concrete support plinths are required under each corner
- As per the Model J1300 KCJ modular plant, a Derrick® Stack Sizer™ screen was selected (in this case with 4 decks to handle the higher throughput rates), but in order to fit this larger unit into a container module it was necessary to redesign the discharge chute work (see Figure 16). The redesign of the chute work was conducted by Downer EDI – Mineral Technologies with input from Derrick Corporation and, if the need arises in the future, a 5-deck Stack Sizer™ screen could be fitted into a container module with the redesigned chute work
- In order to eliminate the need for electrical staff to travel to site for commissioning, all electrical cabling was connected via decouplers into purpose built enclosures (see Figure 17)



**Figure 15 – Suspended sumps integrated into container module structure eliminating the need for structural bracing.**



**Figure 16 - 4 deck Stack Sizer™**



**Figure 17 – Electrical connections between modules.**

An MCC / PLC control room was designed into a container module structure and fitted with fire resistance “Rockwool” thermal insulation and an air-conditioning system. The plant was fully assembled and workshop tested on water prior to being shipped to the first test / demonstration site. Site assembly takes approximately 3 days with commissioning taking a further 3-5 days depending on how ready the site is in terms of services and product & tailings discharge infrastructure.

#### **SUMMARY**

In special circumstances, using a modular plant can offer both cost and schedule advantages to a project. In cases where the plant will be moved regularly from one site to another, using container modules can offer further advantages to the project by minimizing transport costs and site set up time. Container certification is a hurdle that has to be overcome if purposes built container structures are to be designed and built. By incorporating innovative design features into the plant, sufficient operating and maintenance space can be achieved. A container module plant offers significant advantages to a site trial / demonstration plant due to reduced shipping costs and ease of site assembly.

#### **ACKNOWLEDGEMENTS**

American Bureau of Shipping – Container Certification

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Royal Wolf Pty Ltd

Derrick Corporation (NOTE: Derrick® is a registered trademark of Derrick Corporation)

Downer EDI Engineering

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