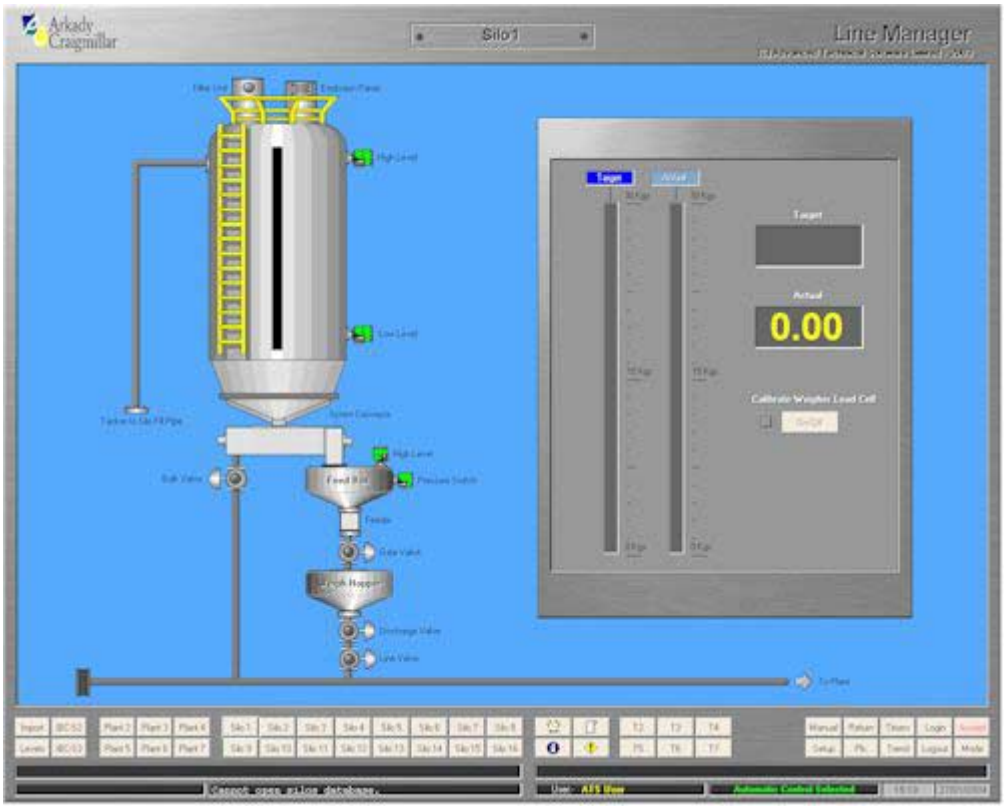
Plant-wide Control System for BakeMark Limited

Advanced Technical Software Limited have recently commissioned a plant wide control system for Arkady Craigmillar Limited at their Manchester based factory.

Focussed on the manufacture of bread improvers of around 17500 tonnes per annum. The plant has now expanded to manufacture an additional 10000 tonnes per annum of predominately cake mixes.

The facility receives, stores, dispenses and tracks ingredients used in the production of food additives, covering control of raw materials, receipt into silos and other stock import in bulk bags, boxes, and drums. In addition the system caters for import of fat based ingredients and also re-work material that is to be re-introduced into the system.

Major Plant Components
There are fifteen storage silos of 10-25-50 tonne nominal capacity plus a dedicated 40T sugar silo and mill. As ingredients vary in characteristics such as explosibility, bulk density etc., flexibility is limited as to which ingredients can be held in which silo. Silos are filled from tanker-based blowers with local land based filtration and dust collection. Associated with each silo is a local weigh hopper for accurately dispensing ingredients up to 25Kg, plus a means of bulk feeding product directly to conveying lines for rapid transfer and weighing at the mixer weigh hoppers.



50 Tonne Storage Silos

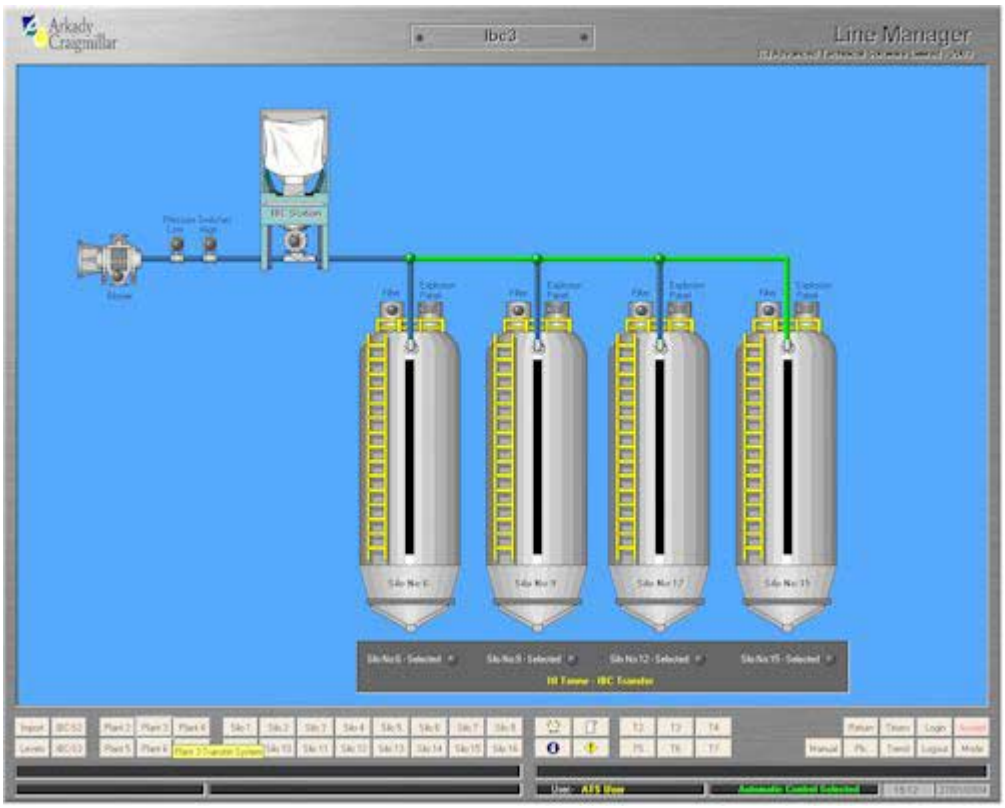
From the 16 silos there are five conveying lines to the six mixer weigh hoppers each capable of receiving a full batch of Ingredients up to a maximum of 2 tonnes. Silos are nominally grouped in threes; with one 50, 25 and 10 tonne silo on each pipeline, appropriate diverter valves etc, allow any silo to feed any mixer weigh hopper.

Each individual batch can have up to thirty different ingredients, the weigh hoppers above the mixers either receive ingredients pre-weighed from the silo dispensing units, or weigh ingredients directly utilising the vessel load cells. Further transfer options include a rigid container feed system, catering for pre-weighed materials and a sack-tip unit allowing hand feeding of pre-weighed bags.

As a batch is started, the dose requirements for each line are added to the end of the appropriate scheduling queue. The queues are scanned continuously to see what can be done next. Each line starts with the top (oldest) requested dose and checks if the destination weigh hopper is busy with any other line or non-silo ingredients and if free, sends the dose.

If the first request cannot be started, the system similarly checks the second and subsequent requests to determine if the line can be utilised. This allows 'queue jumping' and avoids transfer lines being held up for long periods waiting for weigh hoppers to come free.

On completion of a dose, the system removes the satisfied call from the queue. Whenever the system either starts a dose or reaches the end of the queues without being able to start a dose, it then checks to see if any weigh hopper requiring non-silo ingredients is available and if so starts a complete hand ingredient cycle at the sack tip station or feed from the required rigid container. Provision is also included to allow fats or other ingredients to be added directly at the mixer.

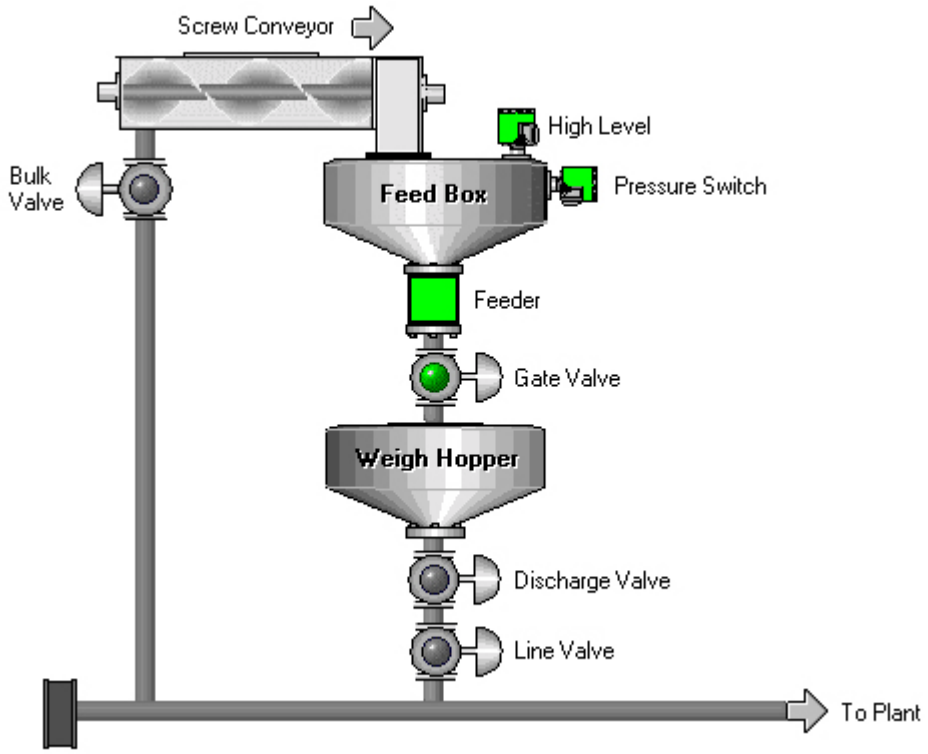


Rigid Container Filling System

Should a silo run empty during a transfer the system checks to see if a substitute silo is available and if so switches to this silo. If none is available or the substitute also runs empty then the system alarms and allows completion of this dose via the use of an emergency pallet. If an emergency pallet is requested the control system will mark the remainder of the required silo amount to come from a pallet unit. The pallet operator then sets up an emergency pallet ready for transfer via the sack tip unit. The emergency pallet facility does not commence until all silo transfers are complete this allows the system to cope with multiple silos running out of material during a single batch.

Weighing Techniques
The core processing function of the system is weighing and batching. Accuracies depend on the weighing equipment specification, however; well-designed weighing algorithms within the PLC are essential.

Each silo has a feed screw, which can discharge either fast or slow, directly into the pneumatic conveying line to a calling mixer weigher. Alternatively it can slow feed in reverse to top up the buffer hopper and feeder. After material is weighed into the silo weigher it is transferred to the mixer weigher.



Silo Bottom Transfer Equipment

In order to achieve accuracy throughout the system, small quantities <25Kg are weighed at the silo and transferred across to the mixer weigher, whilst larger quantities >150Kg are weighed directly into the mixer weigher.

Weights within the range 25-150Kg are weighed using a combination of these techniques. The philosophy is to directly weigh to the mixer weigher as much as possible for speed, but to stop short leaving a small quantity for the small silo weigher to compensate for any inaccuracies.

'In-flight' is the material, which arrives at a weigher after the action has been taken to stop feeding. This is caused by inertia of feed screws, and literally by material being in flight in pipes or falling through the air in the weigher, which land after the feeding stops.

When ingredients are weighed directly into the mixer weighers, the in-flight will be a function of the material and the distance between source silo and destination mixer. The in-flight material will in the main be the material in the pipeline, and will not be affected by the level in the weigher. Hence there is one in-flight per silo to mixer combination. i.e. 96 in-flight values, which are dynamically adjusted after each weighment.

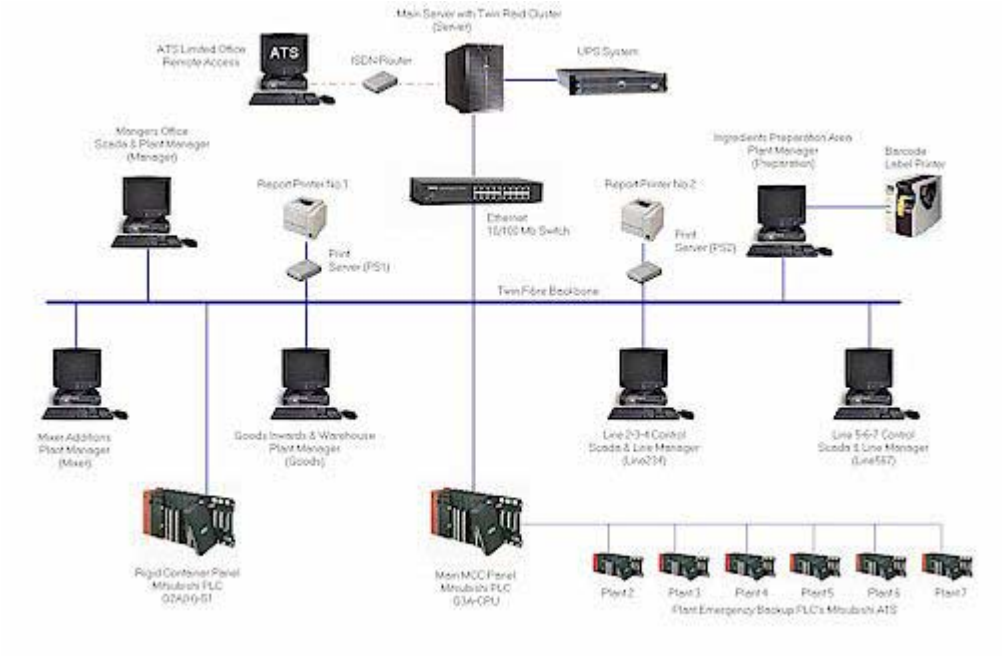
When ingredients are weighed at the silos, there are much smaller quantities involved, and the in-flight material is the quantity falling from the feeder into the weigher. The more ingredient that is already in the weigher, the higher the level, and hence the smaller the in-flight value.

A single value of in-flight for each weigher does not give appropriate compensation throughout the range. To overcome this, each silo weigher has five in-flight bands per silo per mixer, giving a total of 480 dynamically adjusted in-flight values. Using multiple in-flights significantly increases the weighing accuracy.

Plant Wide Control System
The original system installed around 10 years ago, consisted of a master Mitsubishi A3A PLC with six A1S PLC's primarily used for emergency backup purposes, did not have the necessary facilities to handle the increased production and flexibility of the extended plant.
The new automation system covers all materials handling, storage, weighing, batching and blending and tracing of over 2000 different ingredients in use, as well as tracking over a million individual items throughout the factory.

The contract included control panels, continuous level monitoring, network equipment, PLC's, SCADA and a bespoke windows application distributed over a number of network clients plus all software for the complete automation system.

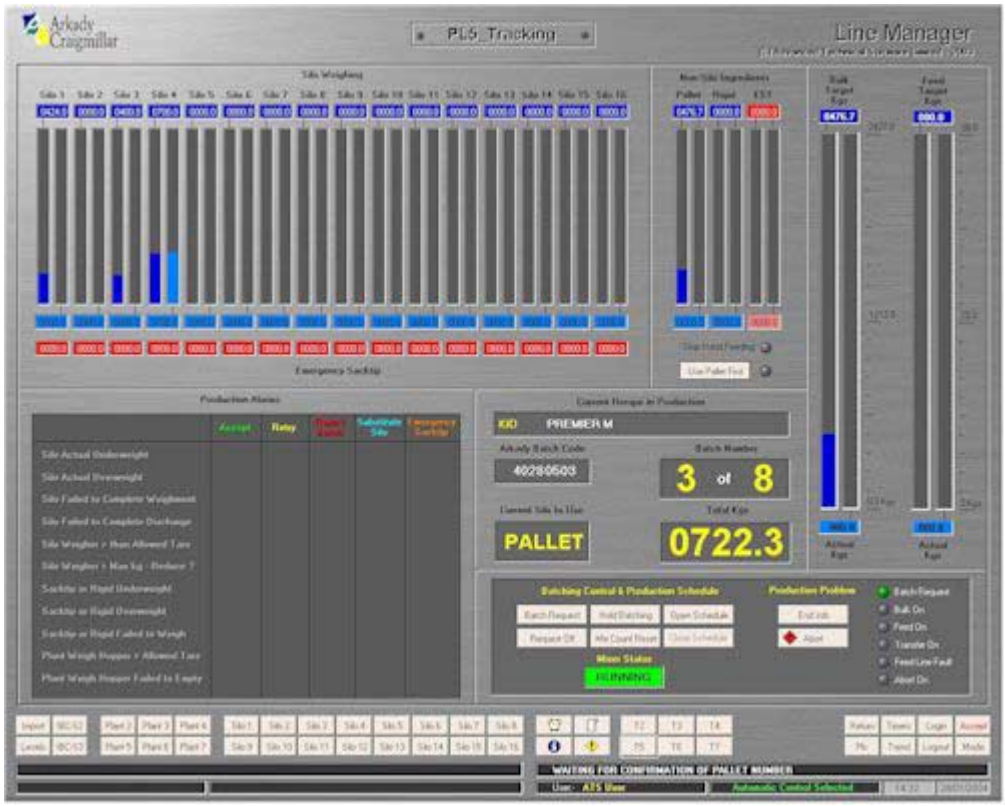
Equipment Layout



As the whole factory is totally dependant on the control system a high quality server was installed with inbuilt redundancy via dual power supplies, memory, and disc storage via six hard drives organised as two raid clusters.

The new system retained the existing plant I/O, however, the main processor was upgraded to the latest Q series and PLC to PLC communications upgraded to Ethernet. The new Q series processor was programmed using Mitsubishi IEC Developer software, which allowed standard program blocks to be designed and re-used for many of the sophisticated control functions.

Automation Software
Although most SCADA packages include some form of product batching and control the very specific requirements for this plant precluded their use. Based on our extensive experience on this type of plant it was decided to distribute the control operation into two distinct areas.
ATS developed a bespoke software application called 'Plant Manager', which handles all material imports, the ingredients preparation area and mixer additions. It also provides administration facilities, to handle recipe set-up, materials tracking and reporting.



Mimic showing a single production line

Each production line is also supported by it's own PC running 'Line Manager', developed by ATS using Citect SCADA. Each line is dedicated to a particular mixer; however, any 'Line Manager' can control all production lines dependant on a user's authorisation.

A major feature of the system gives the production manager the ability to pre-determine the work to be carried out over a forthcoming period or shift. It has a capability of storing up to thirty runs for each mixer. Each run of a particular job has a projected start time so that notice can be given of which pallet and/or rigid containers need to be prepared to meet production requirements.
Picture 6 - Mimic showing a single line weighing Status

The 'Line Manager' PC's allow production scheduling on a line basis and also displays all plant status information, mimics, production and plant alarms along with sophisticated maintenance and set-up facilities.

The final choice of SCADA manufacturer was paramount to the success of this very complex project. Although being an approved systems integrator for a number of leading SCADA systems the final choice by ATS and one, which has proved extremely successful, was the use of Citect.

Citect was chosen for four main reasons: -

- Tightly integrated and easy networking
- Facilities for generating complex and scalable graphics using master templates
- Ci-code a powerful inbuilt 'C' like programming language
- Data access and interaction between applications using Citect API function calls

Citect's architecture allows various tasks to be distributed around the network. In this system the main file server acts as the PLC communications hub for all 'Line Manager' systems on the network and allows easy addition of extra client PC's using the inbuilt computer connection wizard.
All data files for 'Plant Manager' and 'Line Manager' are stored on the server in a database format thus allowing extensive file security and backup facilities for all areas of production and plant information from a single secure location.

Security and traceability is enhanced by the use of a log of all user actions that could in any way affect product quality or system performance.

Reporting & Traceability
The system allows authorised users to request a number of reports. All reports are generated using industry standard Crystal reports, these allow full traceability of all materials and their location. For materials already used in production the reports allow backwards tracing from an individual product batch code.

The system includes very detailed plant alarm and diagnostics allowing even an inexperienced operator to quickly pinpoint any plant malfunction or fault condition. Normal advanced alarm facilities are included but these are supplemented by an on-screen status monitoring and diagnostics panel for each plant item showing it's current status and maintenance information.

System Testing & Simulation
As a continuous three shift production plant a major concern for the client was the length of down time that would occur when the new system went live. Obviously, completing the changeover and restarting production in the shortest possible time was critical.

Advanced Technical Software Limited used 'Trial Run', their own integrated PLC testing and plant simulation software package, which allowed the system to be tested and proved in an office environment. After testing, the same simulation was used to train the operations staff in near 'real world' conditions.

After some pre-commissioning checks on the newly installed plant and control equipment, the full system changeover was completed in less than 48 hours and enabled the return of a fully operational plant with the minimum of problems.

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