TEXTRON Power Transmission

DAVID BROWN ENGINEERING

BALLOON WINCH SYSTEM

OPERATION & MAINTENANCE MANUAL

Contents

1 System Overview.

1.1 Unit Identification and Specification.

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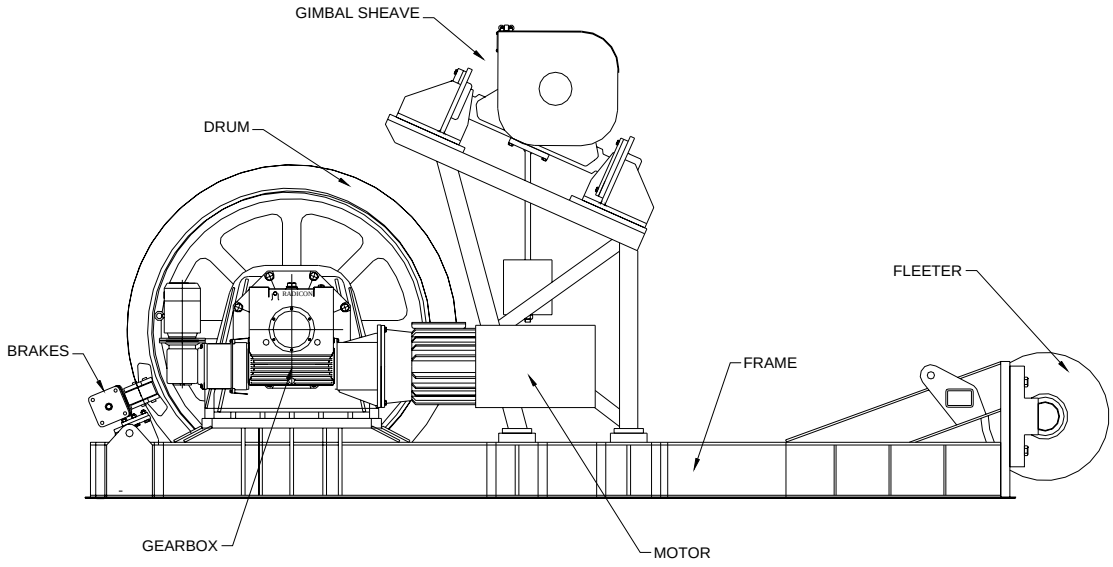
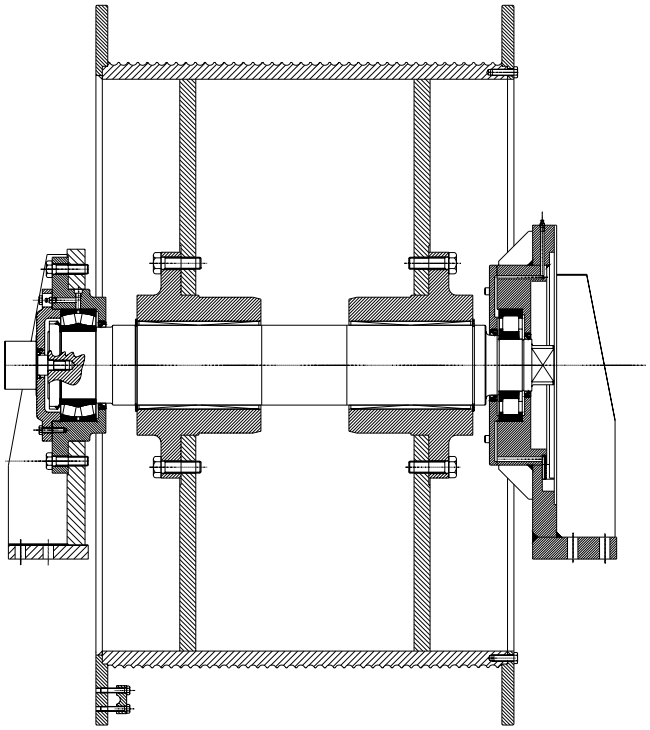
This winch has been designed as a passenger carrying balloon winch, which forms part of the Lindstrand Balloons Ltd Hi-Flyer system. The system should be used in accordance with Lindstrand Balloons Ltd operations manual.



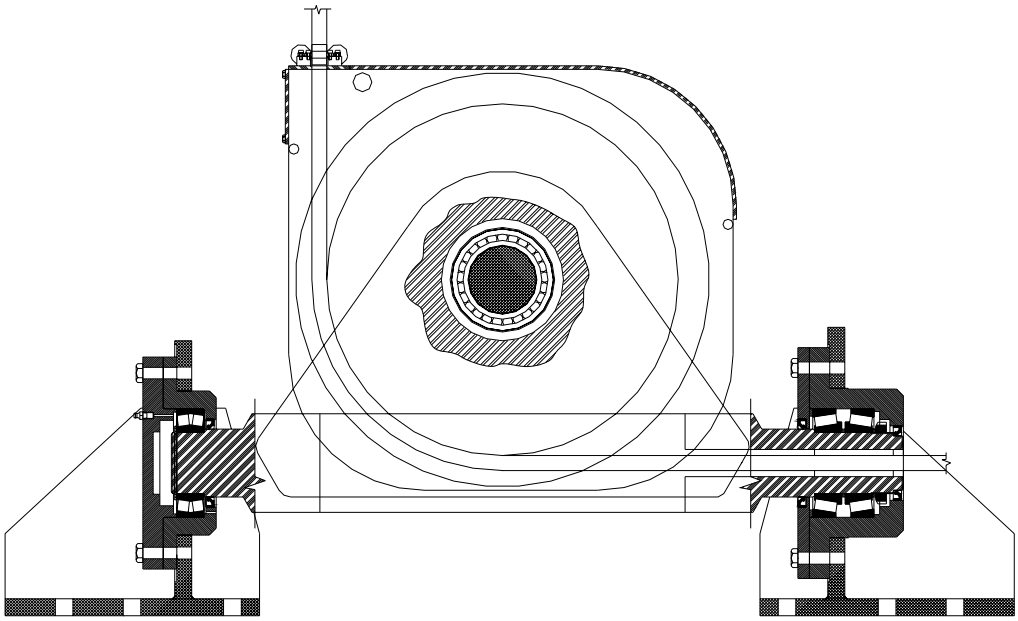
Standard Ground Mounted System

A large single wrap drum stores the full 180m of 22mm diameter steel cable; the rope is stored in a single layer to avoid crushing damage which can occur on multi-layer systems. The drum is held in place by two fabricated bearing supports at each end, which in turn are bolted to the main frame. Hydraulic brakes are mounted at the back of the winch, these brakes are capable of stopping and holding the balloon should all other systems fail. The load is transferred from the drum through two epicyclic gearboxes and a David Brown worm gearbox to the main 37Kw motor. The motor is equipped with a failsafe brake, which can also stop and hold the balloon in the case of an emergency.



Drum Assembly

The rope passes off the main drum to the fleeting sheave; this is a simple screw type fleeter which moves from side-to-side to help guide the rope onto the main drum.
The final assembly before the rope exits the system and is connected to the balloon is the gimbal sheave; this device allows the balloon to drift in any direction without putting a twisting stress into the steel cable.



Gimbal Sheave Assembly

1.2 Technical Specification

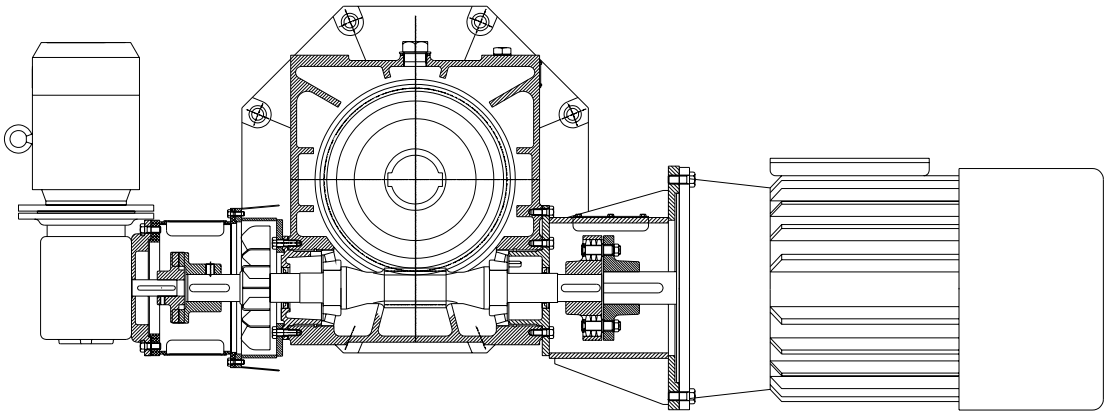
- Safe Working Load 7 Tonnes
- Proof Load tested in the factory and on site to 9 Tonnes
- 22mm diameter "Dyform" rope proof tested to 16.9 Tonnes
- Maximum Cable Speed of 35 metres per minute
- Rope Capacity of 180 metres on a single layer deep grooved drum
- Direct braking by means of fail-safe spring applied disc brakes acting directly onto the drum
- Soft start and stop 'ramping' electronically controlled and variable
- Fixed pendant and remote control operation
- Emergency stop sensors to detect abnormal operation
- Full dynamic braking on the main motor, with heat dissipation into a separate resistor cabinet.
- Computer controlled with graphical user interface (GUI).

1.3 How the System Works.

The winch is controlled by a complex electrical system; the control panel continuously monitors the status of the winch, even when it is stationary. Listed below are the main electrical components on the winch, and a brief description of why they are there, and what they do.

1.3.1 Main Motor

The main motor is the device, which turns electrical energy into mechanical movement. The motor is linked through the gearbox to the drum. The gearbox gives a reduction ratio of approx. 232:1. Which means that the motor has to turn 232 times to get one revolution of the winch drum. The motor is controlled by an electrical device called an inverter (also known as the ‘drive’). The inverter allows the system to control the speed of the motor accurately from 0 – 1500 revolutions per minute (RPM). Mounted on the back of the motor is an electrical rotary encoder, the encoder converts the rotary movement of the motor to electrical pulses and then sends the information back to the drive. Should the speed the being monitored by the encoder differ from the speed the drive is instructing the motor to run at, the drive will report a fault and then shut the system down.



Main Motor & Gearbox

1.3.2 Auxiliary Motor

The smaller auxiliary motor at the back of the winch system is designed to recover the balloon at a much slower speed should the mains power fail, or the main motor or drive fail. It will take approx. 1 hour to recover from full ride height on the auxiliary motor, this is due to the limited power of the 3Kw motor in comparison to the 37Kw main motor.

1.3.3 Hydraulic Brake pack

The hydraulic pack develops the pressure required to remove the hydraulic brakes (approx. 80 Bar). When the control system requires the brakes to be retracted, two electrically operated solenoid valves open and allow the pressure to build up. A pressure sensor detects when the pressure reaches 85 Bar and reports this to the control system. The control system then turns off the motor on the hydraulic power pack. Should the pressure then drop below 75 Bar the control system will detect this and then switch the motor on until the pressure reaches 85 Bar again.
It is quite normal for this cycle to happen a couple of times during a ride, but If it is happening frequently, this could be due to a leak in the system.

1.3.4 Overspeed Encoder.

The speed encoder is mounted directly to the main drum shaft, similar to the encoder on the main motor this device converts rotary movement into electrical pulses. Should the speed of the main drum exceed the maximum ride speed a device in the main panel (PDZ Unit) will detect this and trip the E-Stop circuit.

1.3.5 Rope Overtravel Switch

This switch is set to trip if too much cable is wound off the drum. Should the switch be activated the E-Stop circuit will be tripped and the system will stop.

1.3.6 Fleeting Sheave Over-Payin Switch

This switch is tripped if the fleeting sheave moves too far towards the main frame. It's purpose is to stop the sheave from jamming up against the main frame. As errors creep into the sheaves position due to rope stretch and the sheave being moved as the balloon is moored and un-moored the position may need adjusting from time to time.

1.3.7 Fleeting Sheave Over-Payout Switch

Should the fleeting sheave be adjusted out of position either this switch or the over-payin switch will detect it and trip the E-Stop circuit. The over-Payout switch also acts as a backup for the Rope Overtravel switch and would trip if too much cable is wound out.

1.3.8 Gimbal Sheave Proximity Switches

Two inductive proximity switches are used to detect 5 holes in the side of the side of the actual sheave. As the sheave rotates, the two switches detect each hole as it passes. These signals are returned to the control panel, where the PLC (Programmable Logic Controller) converts them into distances. The controller then adds each count onto a running total to check where the balloon is. The controller keeps two totals, one from each switch. (These two counts are displayed as balloon height 1 & 2). If a discrepancy of more than 3 meters is detected the system will stop the ride, and only allow the balloon to descend at slow speed. Also if the PLC detects too many counts in a 5 second period, the system will register an overspeed and shut down.

1.3.9 Telescopic Limit Switches

Two switches are mounted at the top of the gimbal sheave. If the winch attempts to wind in too much cable, the aluminium disc will hit the two switches and trip the E-Stop circuit. The disc would then need to be removed to allow the system to reset and ascend, the disc would then have to be re-fitted in it's original location.
When tripped together these two switches will also reset the ride height to zero, so care must be taken not to accidentally trip these switches while the balloon is in the air, as the system will presume the balloon is landed and reset height to zero.

1.3.10 Ultrasonic Proximity Sensor

One ultrasonic switch is mounted near to the point where the cable exits the gimbal sheave. The switch is also referred to as a 'photo eye'. During normal (automatic) operation of the winch, the switch detects the aluminium disc when the balloon has landed and stops the ride. The sensor is only active while the balloon is below 8 meters, and so does not have any effect while the balloon is travelling at full speed.
The other function of the sensor is to 'datum' the balloons position after each ride. When the switch senses the aluminium disc, the PLC resets the balloons height to zero, regardless of what height the system thought it was at.

1.3.11 Emergency Stop Circuit

The system is equipped with a complex emergency stop system. This part of the system is designed to monitor certain internal components, and external hard-wired switches to detect any abnormal operation. This part of the system is fail-safe and self-monitoring, so the only way for it to fail in a safe condition would be for

simultaneous failure of multiple components. The categorisation of devices within the emergency stop circuit is Level 4, which is the highest safety rating categorisation.

2 System Maintenance.

2.1 Structural Maintenance

The system is mounted on a concrete plinth and bolted directly to the floor with 18 M24 foundation bolts. As the frame and concrete floor settle, it is likely that some of the foundation bolts will become loose. As the main winch weighs more than the lift of the balloon, the winch is not likely to start to lift, but it is possible that stresses within the winch system could cause the frame to buckle. A monthly inspection should be made of the foundation bolts, and any loose bolts should be tightened.

Monthly inspections should be made to aid in rust prevention & treatment. Any significant damage to the paint system should be cleaned, prepared and painted in line with the paint manufacturers instructions. Paint in aerosol cans is supplied with each system, and further supplies can be obtained from Lindstrand Balloons Ltd. Any areas that have become oxidised should be cleaned back to bare metal and re-painted as per paint manufacturers instructions.

To maintain the appearance of the winch system in general all un-painted metallic surfaces should be treated with a rust preventative substance to avoid discoloration or oxidisation of the surfaces.

NOTE: The main brake flange of the drum should not be treated with any substance whatsoever, this part of the system will become oxidised, unfortunately there is no way of preventing this without affecting the performance of the brakes.

During the monthly inspections of the frame, detailed inspections should be made of the main fabrication and load bearing parts and any abnormalities found should be reported to a David Brown representative. The system operation should then cease until the abnormality has been inspected by a David Brown engineer or authorised representative.

Note : From time to time access will be required over the main drum, it is important that care is taken to ensure the rope is not damaged in any way while accessing these sections of the winch. Damage can occur by the dropping of tools and equipment onto the rope, but more likely by abrasive dirt, such as grit or metal particles contaminating the rope. Because of this, it is advisable to cover the rope with a protective cover while accessing these areas of the winch.

Care should also be taken when moving around the container to ensure that any ancillary devices do not become damaged. Particular care should be taken not to stand on the main motor cowl or the hydraulic motor at the rear of the main drum. These items are not designed to take such loads.

If any maintenance work is to be carried out in the container a detailed inspection should take place afterwards to ensure no tools have been left in or around the winch area. Also any maintenance carried out should be recorded by the engineer on the daily log sheet.

3 Preventative Maintenance.

3.1 Mechanical Maintenance.

This David Brown winch system has been designed and built to give many years of safe, reliable service. Only the highest quality parts have been used in its construction, combined with the skills of a world leader in the design and manufacture of power transmission products. The majority of this assembly is maintenance free, however it is important that regular inspections are conducted to identify any possible failures before they occur.

Maintenance on any load bearing parts should not be attempted by anyone other than a David Brown engineer, unless written authority has been granted by David Brown Engineering. Any attempt made to repair the winch system may endanger the passengers and may void the warranty.

The maintenance program is broken down into four sections, daily, weekly, and annual inspections. A checklist is to be completed for each inspection.

3.2 Daily Inspection.

The results of each daily inspection shall be recorded on the daily winch inspection form. Refer to Flight Manual (TAOM) Appendix 2, sheet A2-6 for a template of the form.

3.2.1 Tether Cable

No fraying or loose wires, especially check the cable wear portion from the swivel down to the winch for signs of wear. Check the complete length over the surface of the drum.

Check cable termination socket for signs of cracks, damage or wear. A specialist cable engineer should be called in if there is any evidence of the above. The cable shall be re-terminated if the connection is deemed to be below strength.

Check cable aligned in groove at bottom of drum and sheaves and correctly positioned through all subsequent rollers

Carefully inspect the whole tether cable for the following:

Slip
Check to ensure that the cable not slipping. This may be carried out by putting a chalk mark across the fleeting sheave and the cable when the empty gondola is at the top landing and observing the relative movement between the marks on the cables and the sheave after one complete cycle (i.e. balloon to full ride height and return to ground).

Diameter
Check the cable diameters close to the cable anchorages as well as the main body of the cable which continually travels through the gimballed sheave. This will enable the effects of bending and resultant wear to be more accurately assessed. (The cable diameter when new is 22mm)

Pay particular attention to those portions of cable on the sheaves when cable tensions are at their greatest (e.g. empty gondola accelerating away from platform).

Wire Breaks
The whole length of each cable should be examined. The maximum number of wire breaks per cable lay length should be recorded. Particular note should be made of any isolated groupings of wire breaks.

Discard Criteria
Cables are usually discarded because of broken wires and/or wear, but other factors, such as reduction in diameter, corrosion and excessive stretch, may also give rise to discard. All of these factors should be taken into account when assessing the condition of a set of cables and deciding if they can remain in service.

Broken wires
The table below indicates the maximum number of broken wires per lay length which can be allowed in the worst section of cable. If the cable is also deteriorating due to other reasons, the numbers of allowable broken wires in the tables will need to be reduced.

Wear and age
These are two factors which should be given particular attention dependent upon the operating conditions and type of drive. Replacement should be considered if, in the case of a traction drive, a reduction of more than 6% (based on nominal diameter) is recorded.

No definite guide to the life of a tether cable can be given but particular care should be excercised where cables have been in service for more than 10 years.

Unusual features
If unusual features are evident which might suggest the onset of failure, replacement must be considered.

Two examples are:
a) Cables exuding a red dust or rouge
b) A local reduction in diameter.

Broken wires per lay length	**Ropes wearing but serviceable**	**Report for ordering and replacement***	**Replace immediately**
Rope construction	6 x 19	6 x 19	6 x 19
Broken wires equally distributed around the strands	< 12	> 12	> 24
Broken wires predominant in 1 or 2 strands	< 6	> 6	> 8

Note: If any wear or damage is evident, all passenger rides shall be terminated until the cable is repaired or replaced by an approved engineer.

3.2.2 Check that swivel and loadcell connections are tight and secure and there is no evidence of damage or wear. Grease the swivel and check that the rotation is smooth and uninhibited.

3.2.3 Check the main winch frame. There should be no evidence of cracks, distortion, damage or wear.

3.2.4 Visually inspect (with the main power off) that the main flange disc breaks are applied to the drum flanges. This can be done by trying to move one of the callipers, if it is possible to move this by hand the brakes are not correctly applied and the fault should be rectified before any operation takes place

3.2.5 Check the brake lines and hydraulic power pack for signs of leaks, repair any leaks and replenish the main hydraulic tank. The hydraulic oil is a mineral based hydraulic fluid, and should be readily available from any hydraulic supplier or commercial garage.

3.2.6 Check the main storage drum & outside edge of rope for signs of wear or damage. Check the drum through its full length and 360^{o} circumference to ensure the rope is not tangled or has dropped out of its groove. The rope must not be subjected to any loads until it is seated correctly on the drum.

Note : If the rope is subjected to any form of stress due to the load being applied when the cable is not seated correctly on the drum or sheaves, David Brown advise that the section of rope should be cut off, and the rope returned to the UK for re-termination and proof test, or that the whole rope be replaced

3.2.7 Inspect the fleeting sheave for any damage or deep grooving. If any grooving deeper than 3mm (0.125") is visible the system should not be used and David Brown should be contacted to inspect the damage.

3.2.8 Check the position of the fleeting sheave, the side of the sheave should be approximately 5mm away from the lower limit switch. Check that the threaded section of the fleeter shaft is suitably greased and not contaminated with sand etc. It should be possible to rotate the sheave easily by hand, if this is not possible it would indicate that the thread is contaminated with dirt. The easiest way to clean the thread is to operate the balloon up to 20M, clean the thread that is then exposed. Bring the balloon down to the ground and then clean the rest of the thread. This process should be repeated several times, purging the sheave with clean grease each time

3.2.9 Check the gimbal sheave entry rollers for signs of wear or damage. Any indentations of the roller surface of more than 3mm (0.025"). If the rollers wear more than 3mm they should be changed for new ones. If excessive wear is permitted to occur this may result in the rope binding on the hole through the gimbal shaft, subsequently rope damage may occur resulting in the necessity to renew the rope. Excessive wear of these rollers could also be signs of problems with the fleeting sheave.

3.2.10 Check the operation of the gimbal sheave rotation. The sheave should move freely around the centre line of the gimbal shaft by moving the counterweight from side to side. The two covers should move back and forth with the minimum of effort (When checking the covers ensure the rope is slack enough to allow movement).

3.2.11 Check for excessive wear of the exit rollers - wear on these rollers may be due to a problem with the side covers not moving freely enough. If the rollers are worn replace and check the freedom of the two side plates, monitor closely in-between flights, if rapid wear occurs the winch must not be operated and David Brown should be contacted. Re-order code - 2 off 158880KA and 2 off 158890KA. If excessive wear is permitted within this assembly it may result in rope damage and necessitate rope renewal, it could also result in the winch safety system being tripped.

3.2.12 On final exit from the container, ensure again that the rope is seated on the drum and correctly positioned through all subsequent rollers and sheaves. If tension is accidentally applied to the cable while it is not located within its proper sheaves and rollers, the rope should be inspected by a suitably qualified engineer

3.2.13 Prior to the first test flight, (when the balloon has been un-moored and all the load is through the main cable), test the ‘holding power’ of the main hydraulic brake by disengaging the motor brake by manually pulling the lever on the back of the main motor. There may be a small amount of gearbox backlash, however, the main drum should not be able to rotate any more than 100mm.

3.3 Weekly Maintenance Schedule

The results of each weekly inspection shall be recorded on the daily winch inspection form. Refer to Flight Manual (TAOM) Appendix 2, sheet A2-7 for the template form.

3.3.1 Check the oil level of the main and auxiliary gearbox. If low replenish with the correct grade of oil (Shell Tivela SC or equivalent 320 grade oil without EP additives). If a substantial amount of oil is needed to top up it should be investigated as to where the oil has gone. The winch may be operated with minor leaks, so long as the oil-level does not fall below the minimum level during operation. A David Brown engineer should be contacted to carry out any maintenance associated with the main geared drive systems.

Note: It is important that the gearbox oil does not contain EP additives. EP additives have a corrosive effect on the materials used in the gearbox, and can lead to premature failure of the gears.

3.3.2 Grease the fleeting sheave, grease should be injected through the grease nipples on the side of the sheave and expel around the screw thread at either side. Grease should also be applied to the full length of the screw thread. Before new grease is applied remove any excess grease from the thread.

3.3.3 Ensure the drum flange on the brake side is clean and free from oil / grease and has no deep score marks. The flanges should be cleaned with a clean dry cloth or paper towelling, no solvent or cleaning solution should be used as this may affect the reliability of the braking system.

3.3.4 Check the operation of the PDZ speed monitor. Open the main panel doors and conduct a test flight. Watch the three status lights on the PDZ unit. The power light should remain on at all times. The stop light may flicker on and off a few times as the brakes retract, but as the winch begins to move it should remain off until the ride stops at the top. The speed light should remain on at all times.

Note: The speed monitor is a safety critical part. If this is found to be operating incorrectly, all operation should cease until the correct functionality has been checked by a David Brown engineer.

3.3.5 Check the operation of the E-stop circuit components using PNOZ Safety relay. Open the main panel doors and watch the LEDs for the channel 1 and channel 2 input. An assistant should individually activate each of the following sensors:

- Fleeting sheave over-pay in switch
- Fleeting sheave over-pay in switch
- Rope overtravel switch
- Telescopic limit switch x 2
- Ground station e-stop button
- Main panel e-stop button

Both LEDs should illuminate for each of the two pole switches,(with the exception of the telescopic limit switches, which are single pole, with one switch per channel). If

the LEDs do not illuminate, this may mean that one of the poles is faulty and operations must be postponed until the fault is rectified.

Note: The safety relay is a safety critical part. If this is found to be operating incorrectly, all operation should cease until the correct functionality has been checked by a David Brown engineer.

3.3.6 Check the braking force of the motor brake. Configure the balloon in the high moored position with the mooring lines attached but without any tension so that the full load is on the main cable. Release the spring applied hydraulic brake using the hand pump and check that the motor brake holds the full load of the balloon.

3.4 Monthly Maintenance Schedule

The results of each monthly inspection shall be recorded on the daily winch inspection form. Refer to Flight Manual (TAOM) Appendix 2, sheet A2-8 for the template form.

3.4.1 Check the operation of the emergency gearbox, to do this it will be necessary to engage the coupling and change the operating mode of the winch - refer to emergency procedure manual for instructions on how to do this. (The auxiliary motor should be tested with the balloon elevated at least 10M and powered by both mains and the emergency generator)

3.4.2 Clean the fleeting sheave thread using a suitable degreaser, ensure the degreasing agent has been thoroughly removed and re-grease the shaft

3.4.3 Grease gimbal shaft support bearings located at either end of the gimbal shaft, inject grease through the M10 grease nipple, excess grease will be expelled through the exit holes at the rear of the housings

3.4.4 Grease sheave bearings (grease nipple located at the centre of the end caps) grease will be expelled through the opposite end of the shaft.

3.4.5 Grease 2 off side plates (grease points on periphery of end caps) grease should expel around bore of side plates.

3.4.6 Grease friction plates - Grease points opposite side plate nipples, grease will expel around sides of friction plates however, this will not normally be visible.

3.4.7 Individually check brake systems.

3.4.8 Ensure the full load is on the main cable, refer to the emergency operating procedures section and use the hydraulic hand pump to manually remove the brakes. The load of the balloon is then transferred to just the main motor brake. It is not uncommon for a small amount of movement to take place during this process, however if the drum rotates more than ¼ of a turn the hydraulic brakes should be re-applied by opening the check valve on the hand pump and the motor brake checked.

3.4.9 Ensure the hydraulic brakes are applied, and the full load of the balloon is on the cable. Pull the emergency brake release handle fully to the rear, a slight noise may be heard from the motor, and it is possible a very slight movement of the drum may take place due to the release of stored energy in the motor coupling. If the drum moves more than ¼ of a turn the motor brake should be re-applied by releasing the brake release handle and the hydraulic brakes checked.

3.5 Annual Maintenance Schedule

Please note that it is a requirement that the system is inspected and overhauled by David Brown at intervals of not more than 1 year. Following completion of this inspection, the system will be re-certified for a further period.

3.6 Recommended Spares

David Brown recommend that the following spares are held on site :-

1, Mechanical

M10x1 Grease Nipples	5 off
Entry Rollers	1 off
Entry Roller Bearings	4 off
Exit Roller Assembly	2 off
Exit Roller Base	1 off
Low Mooring G/Box	1 off
Low Mooring shaft & drum	1 off

2, Electrical

Auxiliary Motor	1 off
Mooring winch motor	2 off
Hydraulic Power Pack Solenoid	1 off
Rope overtravel switch	1 off
Fleeting sheave overtravel switch	1 off
Counter Proximity switch	2 off
24V DC Relay	2 off
110V AC Relay	4 off
Ultrasonic Sensor	1 off
Descend overtravel switch	1 off
Main Motor Encoder	1 off

Replacement of these components should only be carried out by a qualified person. Repairs outside the scope of this manual must be carried out by Authorised Lindstrand/David Brown personnel only

4 Electrical Systems.

4.1 Electrical Maintenance

In general the electrical systems used in the control of the winch system should only be serviced by authorised representatives of David Brown or by Halcyon Drives engineers. However, visual checks can be made of the system and its sensors and the controls reactions to simulated conditions can be monitored.

4.2 Daily Inspection Schedule

- Check all cables for damage.
- Ensure all visible switches and sensors are clear from obstructions.
- Check that no emergency stop switches have been accidentally activated during safety inspections.
- Check the operation of all safety limit switches: - Rope overtravel limit switch, Sheave overtravel limit switches, and gimbal sheave overtravel switches. These switches can be activated with the system stationary, by activating the switch by hand. Confirmation of the switch activating can be monitored, by checking the red light on the reset button goes out.
- Open the cabinet doors and check if any circuit breakers have tripped. Note: Some of the breakers are not reported on the main system display screen, and will only be detected by visual inspection.
- If fitted check that the air conditioning unit is functioning.

Please refer to the control system documentation for any further details of the electronic control system.

Any subsequent electrical maintenance should be referred to an authorised representative of David Brown.

5 Winch System Operating Instructions

5.1 Initial Power Up Procedure.

Once the daily inspections have been completed, the control system may have been left in the off condition. Providing the checks have been completed, the unit can be turned on by turning the isolator switch in a clockwise direction.

Once power has been applied the system will run a short test sequence, this can be seen by the display on the panel door flashing up system info. After approx. 30 seconds the displays will revert to their normal readings. The control will always be in a E-Stop alarm condition after initial power up, this is to ensure no motion can occur until the test sequence is finished. This alarm can be reset by pressing the reset key on either the main panel or ground station. (if the system can not be reset refer to fault finding section).

5.2 Winch Operation.

Once the balloon has been prepared for flight and all pre-flight checks have been completed, the ride may commence.

The operator should depress the ascend button for 2 seconds and then release. There will be a 5-second delay before the winch begins to move, once motion has started the winch will elevate for the first 3 meters at a reduced speed. Once the ride reaches 8 meters, the winch will accelerate up to full speed. The ride will elevate to the set height in fully automatic control, approx. 10 meters before the set height the winch will begin to slow down and gradually come to a complete stop. Approx. 10 seconds after the ride has stopped the main hydraulic brakes will apply.
Once the allotted time has elapsed the ride may be brought down by one single 2 second press on the descend key. The ride will accelerate up to 50% speed for approx. 5 seconds, and then accelerate to full speed. The descent will be fully automatic until it reaches the 3m-safety zone. Upon reaching the safety zone the winch will ramp down in speed and descend to the 1m safety point, at which time the system will stop. Descent can be continued by depressing and holding the descend button. When the rope disc is approx. 500mm away from the sheave sensors the descent will be stopped automatically and the system will reset the ride height to zero. So that accumulative errors are not introduced, it is important that the disc is lowered to the sensors at the end of each descent.

If at any time during the ascent it becomes necessary to stop the ride and return to the ground, this can be done by firstly contacting the ground operator to let them know you are stopping the ride. Then depress the stop button, the system will ramp down to zero speed and stop, after 8 seconds the brakes will apply and the drive will shut down. At this point the ground operator can contact the pilot and tell him he is clear to ascend or descend. The pilot can then ascend or descend the ride by pressing the relevant key. The ride will then ramp to full speed and descend down to the safety zone. Once the safety zone is reached, the ride can be landed in the normal manner.

If at any time during the day the ride is going to be stopped and not used, the E-stop circuit should be activated to stop any accidental or unauthorised use of the system. If the system or site is going to be left unmanned then the main isolator on the system should be turned off.
Whenever the system is going to be low moored the system should be E-Stopped to prevent accidental initiation of the ride which would result in a small amount of cable being payed out without balloon movement.

5.3 Changing the ride Height.

The ride height should only be changed by authorised personnel, the height can only be changed from within the winch container. This is done by pressing the data entry key when at the initial screen. You will then be requested to enter the ride height, which can be any figure between 20 and 120 metres. If any value outside this range is entered, the system will ask you to re-enter a valid height.

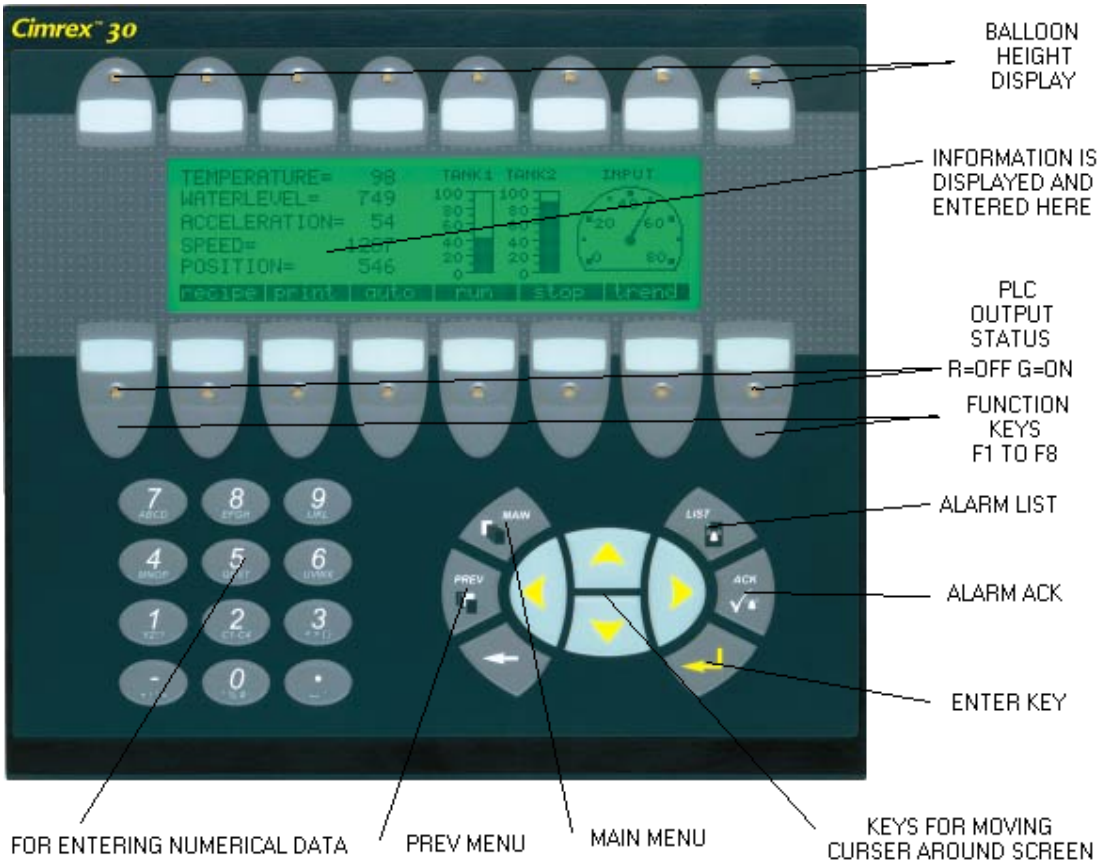
Note : Only attempt to change the ride height while the gondola is on the deck and the disc is over the photo-eyes.

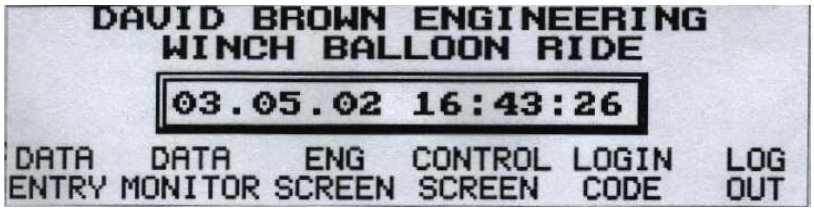
5.4 Controlling the system from the ground controller.

In the event of a remote control unit failure, it may be necessary to lower or raise the balloon using the ground control. This can be done by inserting the key into the remote/local key switch and turning it to local. Once this has been done the remote control unit will become inoperable and the only method of controlling the winch will be by the up/down and stop buttons located on the ground control. These controls are used in exactly the same manner as the remote control buttons.

Note: When in the local control mode the ground station should be manned at all times to prevent un-authorised use. If the system is going to be left unmanned then the E-stop circuit should be activated and control returned to the remote position.

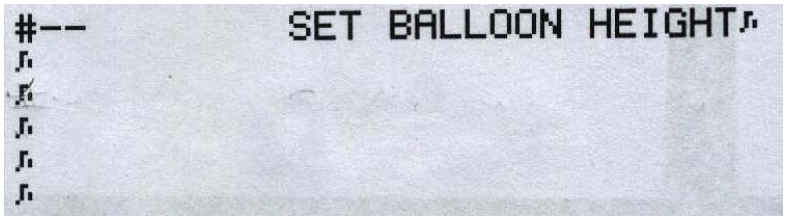
5.5 Graphical User Interface





5.5.1 MAIN MENU

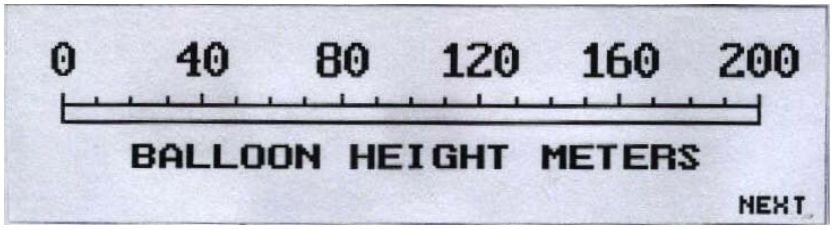
TO SET CLOCK ENTER LOGIN CODE 1, ON NUMERIC KEYPAD START TO ENTER THE DATE AND USING LEFT AND RIGHT KEYS MOVE TO DATA, WHICH REQUIRES THE ADJUSTMENT.



5.5.2 DATA ENTRY

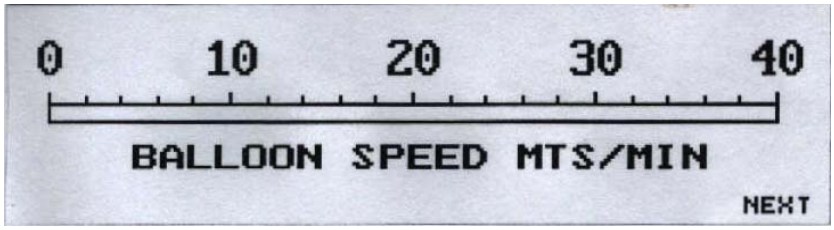
TO CHANGE BALLOON HEIGHT, POSITION CURSER USING ARROW KEYS OVER DATA AND ENTER REQUIRED BALLOON HEIGHT MIN 20 MAX 120 METERS IF THERE IS TWO SETS OF DATA THEN LOGIN CODE 2 IS REQD TO SET TO HEIGHER 160 MTS LEVEL.
PRESS MAIN TO RETURN TO MAIN MENU.

5.5.3 DATA MONITOR



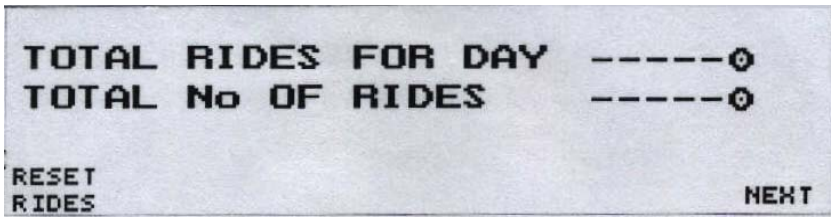
5.5.4 BALLOON HEIGHT

THIS SCREEN DISPLAYS BALLOON HEIGHT. ALSO SHOWN BY INDICATION LIGHTS ABOVE SCREEN DISPLAY. PRESS NEXT TO GET BALLOON SPEED.



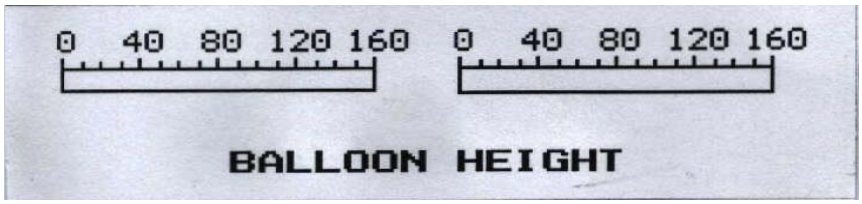
5.5.5 BALLOON SPEED

THIS SCREEN SHOWS THE ASCEND AND DECEND SPEED OF THE BALLOON. NORMALLY THERE ARE ONLY TWO SPEEDS OF THE BALLOON. . PRESS NEXT TO GET RIDE INFORMATION.



5.5.6 RIDE INFORMATION

THIS SCREEN DISPLAYS TOTAL RIDES AND TOTAL RIDES FOR THE DAY THE RIDES FOR THE DAY CAN BE RESET BY PRESSING RESET RIDES. TOTAL RIDES ARE LEFT INTACT. . PRESS NEXT TO GET BALLOON HEIGHT 2



5.5.7 BALLOON HEIGHT 2

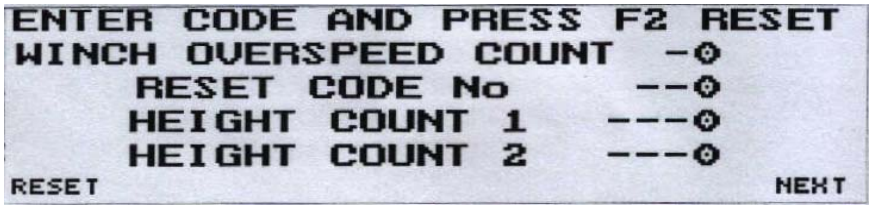
THERE ARE TWO SENSORS MEASURING BALLOON HEIGHT BOTH THESE SHOULD BE EQUAL. PRESS MAIN TO RETURN TO MAIN MENU.

5.5.8 ENGINEERING SCREEN (REQUIRES LEVEL 1 PASSWORD)

TO ENTER PASSWORD PRESS LOGIN AND ENTER THE FOUR DIGIT PASSWORD.

(__ __ __ __) LOGIN 1 THEN PRESS ENTER

THEN PRESS ENG SCREEN.



5.5.9 RESET OVERSPEED TRIP

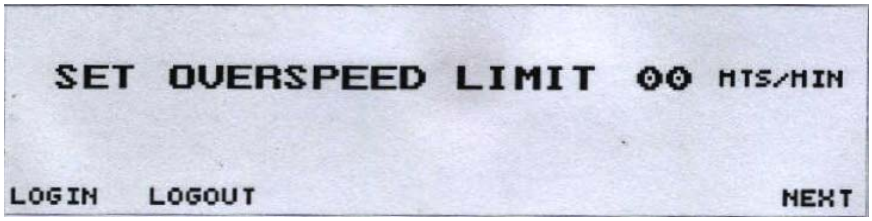
AFTER AN OVERSPEED TRIP, THE COUNT WILL HAVE A NUMBER 1-9 DEPENDING ON THE NUMBER! A CODE CORRESPONDING TO THAT NUMBER MUST BE ENTERED, THEN PRESS THE RESET BUTTON F2.

<u>SET OVERSPEED LIMIT (NEXT SCREEN REQUIRES LEVEL 2 PASSWORD)</u>

TO ENTER PASSWORD PRESS LOGIN AND ENTER THE FOUR DIGIT PASSWORD.

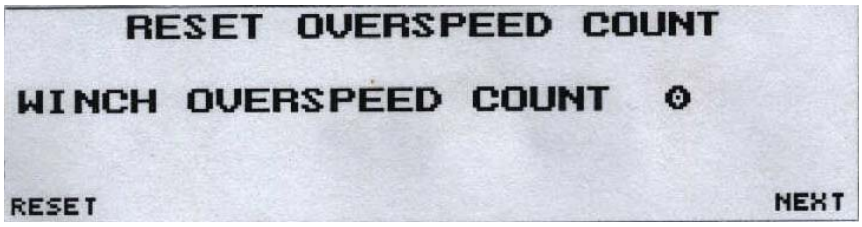
(__ __ __ __) LOGIN 2 THEN PRESS ENTER

THEN PRESS NEXT.



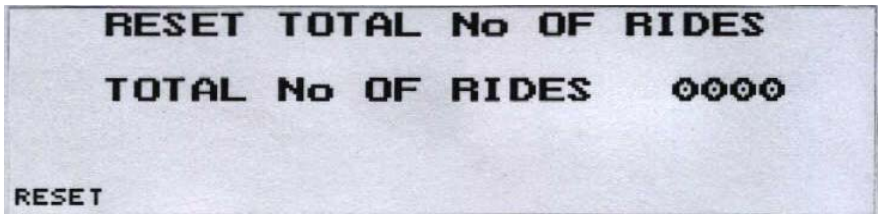
5.5.10 SET OVERSPEED LIMIT. MIN 8 MAX 12

PRESS NEXT TO GET SCREEN (RESET OVERSPEED COUNT)



5.5.11 F2 TO RESET COUNT

PRESS F2 TO RESET OVERSPEED COUNT



5.5.12 RESET TOTAL RIDES

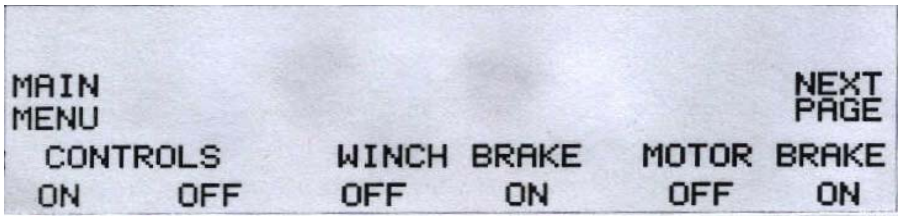
PRESS F2 TO RESET TOTAL NUMBER OF RIDES

5.5.13 CONTROL SCREEN (REQUIRES LEVEL 2 PASSWORD)

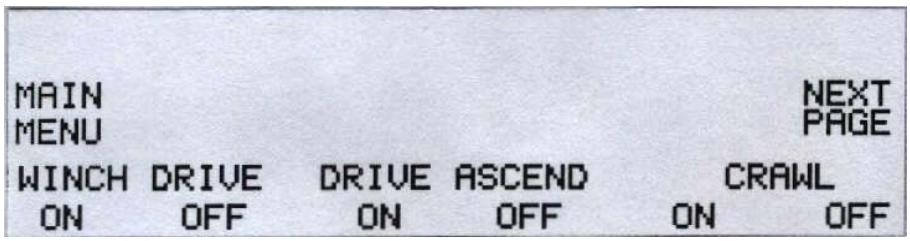
TO ENTER PASSWORD PRESS LOGIN AND ENTER THE FOUR DIGIT PASSWORD.

(__ __ __ __) LOGIN 2 THEN PRESS ENTER

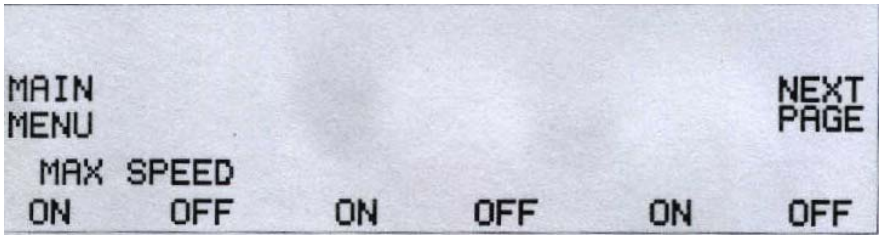
THEN PRESS NEXT.



5.5.13.1 MANUAL BRAKE CONTROL



5.5.13.2 MANUAL INVERTOR CONTROL



5.5.13.3 MANUAL INVERTOR SPEED

5.5.14 LOGIN

PRESS LOGIN THEN ENTER THE FOUR DIGIT PASSWORD DEPENDING WHICH LEVEL YOU REQUIRE. (BOTH NUMBERS CAN BE ENTERED ONE AFTER EACH OTHER.)

(__ __ __ __) THEN PRESS ENTER KEY LEVEL 1

(__ __ __ __) THEN PRESS ENTER KEY LEVEL 2

5.5.15 LOGOUT

PRESS LOGOUT TO PREVENT UNATHURIZED ENTRY. UNIT WILL AUTOMATICALLY LOG OUT AFTER 5 MINS.

5.5.16 ALARM

IF ALARM IS FLASHING ON TOP RIGHT OF THE SCREEN THEN PRESS LIST TO SEE ALARMS. USING CURSER KEYS YOU CAN STEP THROUGH ALARMS. PRESS ACK ON ALARM SYMBOL WILL CHANGE (OR DISAPPEAR IF ALARM HAS BEEN CLEARED), WHEN ACK KEY IS PRESSED. PRESS EXIT OR MAIN TO RETURN.

5.6 Recovering the Balloon using the Emergency Recovery Mode.

In the event that a part of the system should fail which does not affect the main drive system or brakes the balloon can be recovered using the main drive at a reduced speed. This mode of operation will override parts of the E-Stop circuit and must only be conducted by trained personnel.

At all times throughout any of the emergency recovery operations, the operator should act as the final failsafe by monitoring all winch operations. Upon starting the recovery the operator should check that the main drum is rotating in the correct direction (i.e pulling the balloon down) and monitor the system for abnormal noises or operation.

If at any point the operator is unsure about the operation the system should be stopped and the problem investigated further.

Note: The PLC does not monitor the height of the balloon during this process, and as a result the winch will not stop automatically. It is the operator's responsibility to stop the system when the gondola has landed

1, Check that no personnel are in or around moving parts of the winch.
2, Turn the operation mode keyswitch to emergency.
3, Re-set the control by pressing the reset button.
4, Allow the drive approx. 20 seconds to come 'on line'
5, Turn the emergency recovery keyswitch clockwise to the emergency position. The brakes will release and the balloon will begin to descend. Note: The key is non-latching and must be held in the emergency position for the duration of the ride.
6, When the disc is approx. 500mm away from the photo eyes release the keyswitch and the brakes will re-apply and the balloon will stop.
7, E-Stop the system by pressing an E-Stop buttons.
8, Turn the operation mode keyswitch to normal

Note: Because certain parts of the E-stop circuit are disabled when the operation mode keyswitch is in emergency it is possible for the main drive to trip out and allow the balloon to ascend out of control. If this should happen the keyswitch should be released and the E-stop button pressed.
If the operator should accidentally allow the keyswitch to return to the normal position while a recovery is in progress, they should allow the system to come to a complete stop before the key is turned to the emergency position again.

Once the balloon passengers have disembarked, try to rectify the problem, if the fault cannot be identified low moor the balloon and contact David Brown

Refer to section 6.8 before restarting the system

5.7 Recovering the Balloon using Auxiliary Motor & Mains Power.

This method of recovery is used in the event of the main control or drive systems failing, this will be the most likely method of recovery required due to fault on the winch system. This mode of operation will override parts of the E-Stop circuit and must only be conducted by trained personnel.

At all times throughout any of the emergency recovery operations, the operator should act as the final failsafe by monitoring all winch operations. Upon starting the recovery the operator should check that the main drum is rotating in the correct direction (i.e pulling the balloon down) and monitor the system for abnormal noises or operation.

If at any point the operator is unsure about the operation the system should be stopped and the problem investigated further.

Note: The PLC does not monitor the height of the balloon during this process, and as a result the winch will not stop automatically. It is the operator's responsibility to stop the system when the gondola has landed

1. Ensure the Balloon operator and passengers are aware that the balloon is going to be retrieved using a backup system.
2. Ensure the system is E-stopped so that no winch movement can take place.
3. Engage the coupling on the auxiliary motor drive.
4. Turn the operation mode keyswitch to the emergency position.
5. Check that no personnel are in or around the moving parts of the winch
6. Press the reset key and ensure the coupling engaged and auxiliary ready to run lights illuminate.
7. Press the auxiliary motor 'START' button, the main drum brakes and main motor brakes with release and the winch will begin to lower the balloon, once the balloon has landed press the 'STOP' button.
8. E-stop the system by pressing an e-stop button.
9. Disengage the auxiliary motor coupling and secure the guards.
10. Turn the operation mode keyswitch to the normal position

Once the balloon passengers have disembarked, try to rectify the problem, if the fault cannot be identified low moor the balloon and contact David Brown

Refer to section 6.8 before restarting the system

5.8 Recovering the balloon using the auxiliary motor & Generator.

This will be the most likely method of recovery during a mains power failure.

At all times throughout any of the emergency recovery operations, the operator should act as the final failsafe by monitoring all winch operations. Upon starting the recovery the operator should check that the main drum is rotating in the correct direction (i.e pulling the balloon down) and monitor the system for abnormal noises or operation.

If at any point the operator is unsure about the operation the system should be stopped and the problem investigated further.

Note: The PLC does not monitor the height of the balloon during this process, and as a result the winch will not stop automatically. It is the operator's responsibility to stop the system when the gondola has landed

1. Ensure the Balloon operator and passengers are aware that the balloon is going to be retrieved using a backup system.
2. Isolate the main winch system using the isolator on the main panel door.
3. Engage the coupling on the auxiliary motor drive.
4. Start the generator and then switch on the breakers at the front of the generator.
5. Turn the mains / generator keyswitch on the main panel to generator. (The panel should now become live).
6. Turn the operation mode keyswitch to the emergency position.
7. Check that no personnel are in or around the moving parts of the winch
8. Press the reset key and ensure the coupling engaged and auxiliary ready to run lights illuminate.
9. Press the auxiliary motor 'START' button, the main drum brakes and main motor brakes with release and the winch will begin to lower the balloon, once the balloon has landed press the 'STOP' button.
10. E-stop the system by pressing an e-stop button.
11. Turn the mains / generator keyswitch to mains.
12. Turn the breakers on the generator off and stop the engine
13. Disengage the auxiliary motor coupling and secure the guards.
14. Turn the operation mode keyswitch to the normal position

Once the balloon passengers have disembarked, try to rectify the problem, if the fault cannot be identified low moor the balloon and contact David Brown.

Refer to section 6.8 before restarting the system

5.9 Restarting the Main System after an Emergency.

Throughout all of the emergency recovery operations the PLC is not utilised. As a result of this, when the balloon approaches the gimbal sheave the photo-eyes will not detect the disc and stop the system, nor will the height be reset to zero.
When the control system is next powered up the actual balloon height (1 & 2) will read the height at which the balloon was recovered from. If the ascend or descend buttons are pressed the ride will start to operate as if it was at the height showing in the counters, and could result in the system running into the E-Stop sensors on the gimbal sheave.
After any of the three recoveries, the system height should be reset to zero by tripping BOTH of the two telescopic E-stop sensors on the top of the gimbal sheave, the balloon height 1 & 2 counters should then read zero.

6 Mooring System Operation.

The mooring system is a totally separate system from the main winch controller, and will operate regardless of the condition of the winch system. As a result of this it must be noted that any emergency stop control on the main system will not affect the operation of the mooring system.
The panel which controls the mooring system is the left most cubicle of the main winch controller, within the winch container. The isolator for the system is mounted on the top right hand corner, and the system reset button which doubles up as a fault indicator is located in the centre of the panel door.
The 20 mooring winches are supplied with an isolator box, but due to differing site conditions these boxes can be mounted in differing positions, but will normally be within 1 foot of the mooring winch. On each box is an isolator switch, which will isolate each individual winch; there is also a push button, which is used to manually activate each individual winch.
The main controls for the mooring system are located on a pendant control. This pendant control is on a 10m-wander lead allowing the operator to move into a position where he can monitor most of the winches.

The controls and functions are as follows: -

6.1 E-Stop. Located on the bottom of the pendant control.

This button will isolate the complete mooring system. The system will not function again until the emergency stop button has been unlatched and the reset button in the centre of the panel has been pressed.

6.2 Reset Pushbutton

If the E-stop circuit is tripped, this button will reset the system provided the E-stop button(s) have been released.

6.3 Raise / Lower. Toggle switch.

This toggle switch will change the rotation direction of all mooring winches, this includes the direction when operating from the local isolator box push button. It should not be attempted to change the direction of rotation unless all winches are stationary.

6.4 Moor Outer One / All Switch.

This toggle switch will determine the mode of operation for the outer mooring winches. When set to moor all, the winches are controlled from the pendant control. When set to moor one the winches are controlled from the local push buttons at each winch.

6.5 Moor All Outer pushbutton

When the mooring outer toggle switch is set to moor all, and this button is pressed all outer winches will rotate together in the direction set by the raise / lower toggle switch.

6.6 Moor Inner One / All Switch

This toggle switch will determine the mode of operation for the 16 inner mooring winches. When set to moor all, the winches are controlled from the pendant control. When set to moor one the winches are controlled from the local push buttons at each winch.

6.7 Moor All Inner Pushbutton

When the mooring outer toggle switch is set to moor all, and this button is pressed all inner winches will rotate together in the direction set by the raise / lower toggle switch.

7 Description Of Electrical Systems

7.1 Resistor Cooling Fans.

These are the small black fans mounted on the side of the resistor cabinet, which is bolted onto the top of the main control panel. These fans ensure a constant airflow around the resistor elements, to avoid overheating.
The fans run on 110V AC and are fed from an internal transformer. An inline MCB is fitted to check for failure of any of the motors. Any fault of these motors will not be reported on the main control system, but could result in the brake resistors becoming too hot. Temperature sensors protect the resistors, so the likely result of fan failure would be a resistor over temperature alarm.

7.2 Air Conditioning Unit

The air conditioning unit is fitted to systems, which are located in areas with ambient temperatures over 40 degrees Celsius or high humidity levels. The unit is set to keep the ambient temperature below 40^{o}C; it does not cool the system much below this. In areas with high humidity the purpose of the unit is to stop moisture developing within the control panel, if the unit is set to run under the dew point temperature a possible problem is that when the doors are opened the air will condense on the components, which could result in serious damage.
Faults with the air conditioning unit are not detected by the control system, and could result in overt temperature alarms activating on the main invertor, but most likely would not result in any problems. For this reason the units operation should be checked on a monthly basis.

7.3 Radio Modem

The radio modem is used to receive signals from the other modem mounted in the gondola. There are several diagnostic lights, which have the following meanings: -

Power	The unit is being supplied with 12V DC
Rx	The Unit is receiving Data
Tx	The unit is transmitting Data
Carrier	The unit has established connection with the other modem

Any fault on the radio modem will result in the ascend, descend and stop buttons on the gondola becoming inoperable. Due to the complexity of this part of the system the ride should be operated on the ground station, and the manufacturer should be contacted.

7.4 110v Transformer (TX101)

This transformer supplies the 110v control voltage for the whole of the system when running in normal mode. Failure of this transformer would result in total loss of all system functions and only ancillary equipment such as the fans, air conditioning and hydraulic brake motor will function.
The transformer supply is then split into several circuits, which are fed from MCB's within the main panel.

Q109 12VDC PSU (Radio Modem Supply)
Q108 Resistor Cooling Fans & Main Panel Fan
Q107 Internal 13amp Socket (Engineer use only)
Q106 PLC Microprocessor & PanelView Display
Q105 PLC Controls
Q104 Controls
Q103 Controls

7.5 KM201 and KM202

These two relays are used to select between mains and generator supply. These relays are connected so that it is not possible to energize them both at the same time, if this were to happen there would be a risk of crossing the mains and generator supplies, which could lead to serious damage to the control system.
When KM201 is energized and KM202 is not, the system is supplied by the generator, and when KM202 is energized and KM201 is not, the system is supplied by the mains.
There are two breakers in-line with each supply (Q201 & Q202), if these breakers are tripped the power to all 3-phase devices will be lost, however the control system will still function as the 110v supply is taken before these breakers.
Failure of one of these relays would result in loss of either mains or generator supply.

7.6 110v Transformer (TX201)

This transformer has the same function as TX101, except that it does not supply the PLC system with power. While on generator supply it is only possible to operate the auxiliary motor, and for that reason this transformer will only supply 110v to the parts of the system required for an auxiliary recovery. Having a separate transformer also give the system a backup should TX101 fail.

7.7 Brake Hydraulic Motor

The hydraulic motor is the electric motor mounted on the top of the hydraulic power pack used to release the hydraulic brakes on the main drum. This motor should be rotating all the time that the brakes are applied. When the brakes are energized (SOL1 & SOL2) to allow the winch to move, the hydraulic pressure builds up to 85 BAR at which point a sensor (PS1) de-energizes KM701, which turns off the motor. Should the pressure then drop below 80 BAR PS1 will then re-activate KM701 and build the pressure up to 85 BAR again.
The motor is protected from overload by the breaker Q301. Failure of any components within this circuit will result in the system not being able to remove the hydraulic brakes on the main drum.

7.8 Auxiliary Motor

The auxiliary motor is the motor mounted at the rear of the winch gearbox, and is used to recover the winch in the event of a power failure, or a main system failure.
The motor is protected from overload by breaker Q302, and is activated by the relay KM702. The Auxiliary motor control circuit activates this relay.
Failure of any components in this circuit would result in the auxiliary motor being inoperable.

7.9 Brake Unit

The brake unit is the electrically operated brake on the main motor. The brake is applied when KM1201 is not energized, and is removed when KM5 is energized. The unit is protected by the overload Q303. Failure of any components in this circuit would result in the main motor brake not being released.

7.10 Winch Blower Motor

The winch blower motor is the motor, which operates the fan on the main motor. The fan only operates when the invertor is on line, and is operated by the relay KM602. The motor is also protected by the overload Q304. Failure of the breaker is reported to the PLC, however failure of the relay would not be detected and may result in the invertor tripping on over temperature.

7.11 24v DC Power Supply

The 24v DC power supply is a transformer from 110v AC to 24v DC. The supply to the unit is from TX101 or TX201 and the MCB Q401 protects the unit. 24v DC is then supplied through MCB Q402 to the 24v devices. Failure of this device would result in the overspeed unit becoming inoperable (which is part of the E-Stop circuit) and therefore total loss of the system.

7.12 24v DC Health KA401

This relay detects the 24v DC supply and report to the PLC and the E-Stop circuit that the transformer is healthy.

7.13 Speed Monitor

The speed monitor is a complex fail-safe device, which monitors the speed of the main drum by means of the encoder mounted on the side. Should the speed of the drum exceed approx. 120% of the normal running speed, the unit will trip and the E-stop circuit will activate.
Three LED's indicate the units status:-

- Power – 24v DC is being supplied to the unit.
- Standstill – The main drum is not rotating.
- Speed – This light activates when the drum rotates too fast.

Due to the safety critical nature of this device, coupled with the fact that the end user cannot check its operation no attempt should be made to repair or re-configure this device.

- **WARNING:** This item forms part of a safety critical circuit. It is recommended that only persons authorised by David Brown conduct maintenance on this item.,

7.14 Payout Proximity Sensors (1 & 2)

These are the two sensors mounted on the side of the gimbal sheave which detect when one of the 5 holes in the side of the sheave pass the end of the sensor. The two switches are identical and the signals are processed by the PLC. While the sensor is not detecting metal (i.e. the sensor is over a hole) the relevant relay KA402 or KA403 is de-energized. When metal is detected the relay energizes.
To aid in fault finding there is also an LED on the back of the sensor mounted in the gimbal sheave, this can be viewed by removing the cover of the terminal box

mounted on the side of the gimbal sheave assembly. If the system detects a failure on these switches the ride will stop and will only descend, the ride will not function until the fault is rectified.

7.15 Balloon Parked Photo Eye

The sensor is mounted next to the exit roller assembly on the top of the gimbal sheave, when the aluminum disc is within 500mm the sensor is activated and KA404. The relay reports back to the PLC that the balloon has landed and reset the height to zero. Failure of this switch will result in the ride height counters not resetting to zero at the end of the ride, after a few flights this will activate an alarm to say that the counters are not functioning correctly. Checking the relay or the PLC input racks can check the operation.

7.16 Emergency Stop Circuit (E-Stop)

This circuit is the backbone of the electrical system; unless this circuit is healthy the majority of the system will be non-functional. The centre of the E-stop circuit is the Pilz Emergency Stop Relay (ESR). Once healthy this unit will activate the 110v control circuits, and only then will any winch operation take place.
The circuit can be split into three areas as follows: -

7.16.1 E-Stop Loop

The hard wiring of the loop leaves the ESR on wire 50 from terminal S11, this then passes through the Pilz Speed Monitor and then splits into 2 channels. The reason two contactors are used in each switch is to ensure a fault on one of the contactors could not result in the switch becoming inoperable. There are 7 E-Stop sensors on the winch, which are shown on the table below.

Switch Name	Location	Function
Control Panel	Main Panel Door	Push in Emergency
OP Station	Ground Control Station	Push in Emergency
Disc Over travel	Top of Gimbal Sheave	Trip if aluminium disc hits them
Rope Over travel	Main Frame opposite control panel	Trips if too much rope is payed out.
Fleeting sheave over payin	Next to fleeting sheave nearest to main panel	Trips if fleeting sheave is out of position
Fleeting sheave over payout	Next to the fleeting sheave furthest away from main panel	Trips if fleeting sheave is out of position or too much cable has been paid out

Due to the fact that the Standstill Unit is itself a failsafe device only one channel is passed through this device, once the circuit has split into 2 channels both channels

have to be closed to allow the ESR to reset. When the circuit has passed through the hard wired switches, it then returns to the control panel and check on the system status.
Relays KA1206 report on the status of the PLC. If the PLC is not functioning correctly or the PLC program has detected a fault this relay will open.
Relay KA802 detects the status of the drive, this relay differs slightly in the fact that the contacts are normally closed, and open if the drive detects a fault. The reason for this is that when the E-Stop circuit is tripped the drive is shut down, if normally open contactors had been used it would not be possible to reset the system with the drive not turned on.
KA401 reports if the 24v DC supply is present. If 24v DC is lost then the relay will open and break the loop.

In case of a fault on any of the above relays, the emergency operation key switch on the main panel is used to link these out of the E-stop circuit. This will allow the auxiliary motor to recover the balloon should there be an internal fault. However all other limit switches will still function.

7.16.2 Relay Check Circuit

As well as the main E-Stop loop there is also a second loop, which must be closed before the ESR can be reset. This loop checks the status of 5 relays to ensure that the contacts have not been welded (i.e. The relay is stuck permanently on). The relays checked are as follows.

- KM701 & KM702 supply power to the invertor
- KM801 Activates the auxiliary motor
- KM1401 Activates the motor brake
- KA802 Activates the hydraulic brakes

7.16.3 Reset Relay

When either of the two reset buttons is depressed, KA11 is activated which closes the switch between S33 & S34 on the ESR. Providing the E-Stop loop and the relay check circuits are closed the relay will activate and close the contacts within the ESR. This in turn will supply power between terminals 43 & 44, 53 & 54, 63 & 64, 73 & 74. These relays supply voltage to the control systems and will allow operation of the winch system.

7.17 KA701 & KA702

These two relays check that the 110v supply from TX1 is healthy. KA7 checks the voltage from Q103, and KA8 the voltage from Q104. If either of these supplies are lost the E-Stop circuit will be tripped and a fault reported to the PLC.

7.18 Mains on Light

When 110v is supplied to wire 17 the two lights will illuminate. Note that these lights only function from the 110v supply, if there were a failure of TX101 the light would not illuminate – even though there is a 3-Phase supply present.

7.19 Reset Push Buttons

When either of the two E-stop buttons are pressed this operates the relay KA703 and closes the reset loop on the ESR. As can be seen from the configuration of this circuit there is no difference between these two buttons, and it is therefore irrelevant which button is used.
Once the ESR has reset or the lamp test button has been pressed the reset button will illuminate red (see circuit on sheet 7)

7.20 Lamp Test Button

When pressed this will activate KA704, which in turn supplies voltage to all indication lamps on the panel. This allows the user to check if all of the lamps are functioning.

7.21 Auxiliary Motor Clear to Run Lamp

Once relay KA801 is energized (or the lamp test button is pressed) the light will illuminate.

7.22 Winch Drive Enable (KM701 & KM702)

Providing the following conditions are true: -

- ESR is reset
- Breaker Q901 is not tripped
- KA801 (Auxiliary Coupling Detection Prox) is closed
- KM202 (mains power selected) is closed

KM701 and KM702 will energize. These contactors supply power to the invertor. There are two breakers to ensure protection should one of the relays fail in the closed position. Failure of either of these relays will result in no power being supplied to the invertor and no operation of the ride in normal mode. (Auxiliary recovery will still be functional)

7.23 Control Circuits

The following items cover the parts of the circuits that send commands to the devices already covered.

7.23.1 Winch Blower

Providing the following conditions are true: -

- ESR is reset
- KM701 & KM702 are closed
- Q304 is not tripped

KM703 will activate and turn on the fan on the main motor.

7.23.2 Brake Solenoid 1 & 2 (KA802)

When activated these two solenoids allow the hydraulic system to pressurize. Providing the ESR is reset and KA802 is energized the solenoids will activate and release the brakes.
The brakes can also be removed by energizing timer KT801 or relay KM801

7.23.3 Auxiliary Motor Activation

This circuit checks that the auxiliary motor is clear to run. The key switch has to be in emergency mode, Q202 (Mains) and Q201 (Generator) must not be tripped, this will the activate KA801 to show the auxiliary motor is clear to run.

7.23.4 Auxiliary Motor Run

Providing the ESR, KA801 and KA803 are energized the motor can be started or stopped by pressing the relevant button. The circuit energizes KM4 which will start the motor, remove the motor brake (KM1401) and the hydraulic brakes (KA802).

7.23.5 Normal / Recovery Key switch

This key switch is used to recover the balloon in the event of a system failure where the invertor and brake systems are still functional. When energized this circuit will activate the timer KT801 , activate KA802 and KM1401 and also send a run signal to the invertor.

7.23.6 Hydraulic Brake Activation

This circuit is split into three legs; the first leg is used during normal operation.
Providing KA15 (Drive Enable) and KA1405 (PLC output) are energized KA802 will energize and operate the hydraulic brake solenoids. The second leg is used by the normal / recovery key switch and the third leg is used when the auxiliary motor is started.

7.23.7 Pressure Switch (PS1)

This switch monitors the pressure of the hydraulic system and is mounted on the hydraulic power pack. Once the set pressure (85 Bar) has been reached the switch opens and KM802 is de-energized, this switches off the hydraulic motor. Once the pressure drops below approx. 75 Bar the motor is re-activated. It is quite normal for the pump to cycle on and off a couple of times per ride, but is this becomes more frequent it could indicate a hydraulic leak.

7.23.8 Coupling Detection Proximity Sensor

This proximity sensor is mounted to the side of the auxiliary coupling. Its function is to determine if the coupling is engaged. When the coupling is disengaged (system running in normal mode) the circuit is closed and KA803 is energized. This allows

power to the invertor. When the coupling is engaged the power to the invertor is cut and the auxiliary systems are enabled.

7.23.9 Coupling Engaged Lamp

When KA803 is energized or the Lamp Test button is pressed this light will illuminate.

7.24 Invertor

The invertor is the device, which controls the main motor, if this device is not functioning correctly there will be no system operation except for the auxiliary motor.

7.24.1 Power Supply

Power is supplied to the unit from the main isolator through Q901 (80 Amp motor rated breaker) then through KM701 & KM702 and finally through a 125 Amp fused isolator.

7.24.2 Encoder Module

Mounted on the back of the main motor is an encoder, the signal from this device is sent to the NTAC unit mounted in the main panel, just below the invertor. The signal is then returned to the invertor through fibre optic cables. The drive uses this information to confirm the speed that the motor is running at. If there are any errors between the speed the drive is set to run at and the actual speed the drive will shut down and trigger the E-Stop circuit.

7.24.3 Digital Inputs

These inputs are supplied by the PLC outputs. When energized the following relays give a specific signal to the drive

- KA1401 Puts the drive into run mode (if there is no speed selected the drive will hold at 0 RPM)
- KA1404 When not energized the drive will run in reverse, energizing the relay will change direction
- KA1402 Selects 500 RPM speed
- KA1403 Selects 1500 RPM speed

These inputs are also activated when the key switch recovery is used, inputs 1 & 3 are energized through KA804 to start the drive running at 500 RPM in reverse.

7.24.4 Relay Outputs

The relay outputs send signals back to the main system & PLC.

- RO31 Drive Fault (Indicates the drive has detected a fault – This error is returned to the PLC).
- This output also energizes KA902 which is part of the E-Stop circuit.
- RO22 Drive Running (Used by the PLC to confirm a movement command has been processed)
- RO12 Drive Enable (Activates KA15 – Used to report that the drive is ready for operation)

7.24.5 Resistor Bank

When the balloon is ascending the motor does not need to generate power as the balloon us trying to pull the cable out, in fact the situation is quite the opposite as the energy of the balloon needs to be dissipated. To do this the motor is used to generate electricity, and this energy is dissipated through the brake resistors on the top of the cabinet. These resistors are designed to become hot during use, and are protected by temperature sensors.

Note: This part of the system operates at around 600v DC – No part of the invertor should be touched while power is on or within 10 minutes of isolating the system.

7.24.6 Thermistor Relay

The Thermistor checks the temperature of the main motor, if the motor overheats the drive will stop the system until the motor has cooled down. This motor has be designed for continuous running at very high ambient temperatures, if overheating occurs this could indicate problems with the drive, motor or winch systems.

7.25 PLC (Programmable Logic Control)

The PLC is an industrial computer used to control the balloon during normal operation. The PLC consists of the main microprocessor, input slots which detect signals from relays and other devices, and output slots, which send electrical signals to devices within the system.

7.25.1 Microprocessor

The microprocessor is supplied in it's normal operating mode, and should not be tampered with except under the guidance of the manufacturer.

7.25.2 Slot 1

Slot 1 consists of 16 inputs from the following devices: -

- IN0 Detects Payout proximity sensor 1
- IN1 Detects Payout proximity sensor 2
- IN2 Detects Balloon Parked Photo Eye 1
- IN3 Detects Balloon Parked Photo Eye 2
- IN4 Detects that the invertor is enabled
- IN5 Detects an over temperature of the resistor bank
- IN6 Detects an over temperature of the main motor
- IN7 Detects the ESR has been tripped
- IN8 Spare
- IN9 Input from Stop pushbutton on ground control station
- IN10 Input from Ascend pushbutton on ground control station
- IN11 Input from Descend pushbutton on ground control station
- IN12 Input from Local / Remote Key Switch
- IN13 Input from Reset push button
- IN14 Input from Auxiliary Motor Enable Key Switch
- IN15 Input from invertor to signal drive running

7.25.3 Slot 2

Slot 2 consists of 16 inputs from the following devices: -

- IN0 Detects generator overload
- IN1 Detects mains overload
- IN2 Detects hydraulic brakes overload
- IN3 Detects auxiliary motor overload
- IN4 Detects main motor brake overload
- IN5 Detects main motor fan overload
- IN6 Detects winch over speed has been detected
- IN7 Detects E-Stop button on main panel has been pressed
- IN8 Detects E-Stop button on ground control station has been pressed
- IN9
- IN10 Detects disc over travel switch 1 has been tripped
- IN11 Detects disc over travel switch 2 has been tripped
- IN12 Detects rope over travel switch has been tripped
- IN13 Detects fleeting sheave over payin limit has been tripped
- IN14 Detects fleeting sheave over payout limit has been tripped
- IN15 Spare

7.25.4 Slot 3

Slot 2 consists of 16 inputs from the following devices: -

- IN0 Detects 24v DC supply is healthy
- IN1 Detects 110v supply is healthy
- IN2 Detects a fault on the invertor
- IN3 Detects position of emergency recover key switch
- IN4 Detects if auxiliary coupling is engaged
- IN5 System On / Off key switch (Engineer Use Only)
- IN6 Spare
- IN7 Spare
- IN8 Spare
- IN9 Spare
- IN10 Spare
- IN11 Spare
- IN12 Spare
- IN13 Spare
- IN14 Spare
- IN15 Spare

7.25.5 Slot 4

Slot 2 consists of 16 outputs to the following devices: -

- O0 Command to engage invertor
- O1 Command for 500 RPM speed
- O2 Command for 1500 RPM speed
- O3 Command for drive rotation direction

- O4 Command to remove hydraulic brakes
- O5 Command to remove main motor brake
- O6 Command to trip E-Stop circuit
- O7 Command to trip E-Stop circuit
- O8 Spare
- O9 Spare
- O10 Spare
- O11 Spare
- O12 Spare
- O13 Spare
- O14 Spare
- O15 Spare

8 Fault Finding

The PLC control system is equipped with a panel display unit, which normally displays ride height, speed and other related settings. In the event of a system fault the mode of this screen can be changed to display alarms, which will aid in the locating of system faults.
There are 3 alarm screens, which can be accessed by pressing the F2 function keys. The displays will normally list the device name and report that is healthy. If a sensor is tripped or device is not functioning correctly it will be listed as unhealthy on will be flashing.
Below is a brief overview of system alarms and possible failures :-

8.1 Safety Relay Healthy

This alarm refers to the main E-Stop Pilz unit. Normally this alarm would be displayed because another alarm has been triggered. Apart from the emergency recovery key switch no systems will operate until the system has been reset by clearing the alarm and re-setting the system on either the reset button on the ground control or main panel.

8.2 Generator Overload Healthy

This alarm indicates if the breaker for the generator has been tripped. If this breaker should trip during an emergency recovery it should be reset no more than twice and the recovery re-attempted. If the breaker continues to trip the auxiliary motor and associated wiring to the panel, and also the wiring from the generator to the panel should be checked by an electrician. If the motor is found to be faulty it should be replaced with the motor purchased in the spares package, if no spare motor is available it will be necessary to recover the balloon using other means (refer to Lindstrand Balloons Ltd operation manual).

8.3 Mains Overload

This alarm indicates if the breaker for the main incoming power has been tripped, this breaker is rated considerably larger than the maximum current required and if it should trip the balloon should be recovered on the generator and David Brown contacted for advice. Due to the possibility of damaged wiring or components no attempt should be made to re-connect the power.

8.4 Hydraulic Brake Overload

This alarm indicates if the breaker for the hydraulic brakes has been tripped. If this breaker trips it should be reset no more than twice and the ride should be re-attempted. If the breaker continues to trip the brakes will have to be

removed using the emergency hand pump and the balloon recovered on the auxiliary motor. An electrician should then check the motor and associated wiring to the panel.

8.5 Auxiliary Motor Overload

This alarm indicates if the auxiliary motor breaker has tripped. If this breaker trips it should be reset no more than twice and the recovery re-attempted. If the breaker continues to trip the motor and associated wiring should be checked by an electrician. If the motor is found to be faulty it should be replaced with the spare. If no spare motor is available it will be necessary to recover the balloon using other means (refer to Lindstrand Balloons Ltd operation manual).

8.6 Brake Unit Overload

This alarm indicates if the breaker for the brake on the main motor has tripped. If this breaker trips it should be reset no more than twice. If the breaker continues to trip the brake can be held off manually with the release handle and the ride recovered on the emergency recovery key switch. (Refer to emergency operation procedures).

- **WARNING:** This item forms part of a safety critical circuit. It is recommended that only persons authorised by David Brown conduct maintenance on this item.,

8.7 Winch Blower Overload

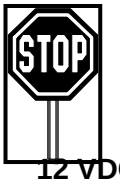
This alarm indicates if the breaker for the motor cooling fan has tripped. If this breaker trips it should be reset no more than twice. If the breaker continues to trip the balloon can be lowered on the emergency recovery key switch (the motor will not overheat while being run at slow speed). As the system checks the operation of this device before allowing the balloon to ascend, it will not be possible to continue operation until the fault has been rectified.

8.8 Winch Drive Healthy

This alarm indicates if the main drive invertor is healthy. If the main drive should fail it should be attempted to reset the system. If the system resets OK try to run the system and watch the display on the invertor - if the system seems to run OK then bring the balloon to the ground and remove the passengers. Attempt another 3 rides with no passengers and watch the 'torque' readout on the invertor panel. If the 3 rides run without problem and the torque is not over 95% with the gondola off the decking then record the incident and resume the ride. If the drive continues to trip or will not reset, recover the system using the auxiliary motor and contact David Brown.

8.9 Winch Drive Overspeed.

This alarm indicates that the system has exceeded it's maximum speed This alarm would normally indicate a serious fault and the balloon should be recovered using the auxiliary motor (not the emergency recovery keyswitch) and not used again until David Brown have been contacted.



- **WARNING:** This item forms part of a safety critical circuit. It is recommended that only persons authorised by David Brown conduct maintenance on this item.,

8.10 12 VDC Supply Health

This alarm indicates that the 12VDC supply is not present. This could be due to the main breaker (Q103) being tripped or the 12VDC transformer being defective. It should be attempted no more than twice to reset Q103 - If the system continues to trip it will not be possible to recover the ride on either normal or emergency mode. The only method of recovery would be to rectify the fault, or supply an external 24VDC supply into the control panel. This work should only be carried out by a qualified electrician.

8.11 110VDC Supply Health

This alarm indicates that the 110VDC supply is not present. This could be due to the main breaker (Q103) being tripped or the 110VDC transformer being defective. It should be attempted no more than twice to reset Q103 - If the system continues to trip the ride should be recovered using the auxiliary motor on generator supply and David Brown Contacted.

8.12 Resistor Temperature Health

This alarm indicates if the resistor cabinet mounted on top of the main control system has overheated. If the resistors should overheat the ride can be recovered using the auxiliary recovery key. The 4 cooling fans on the front of the cabinet should then be checked, if these are functioning correctly and the ride has not been subjected to any abnormally high usage (more than 5 rides per hour) then David Brown should be contacted before the ride is resumed.

- **WARNING:** The resistor banks operate at approximately 600VDC – It is recommended that only qualified electricians remove the covers.
- Refer to ACS 600 documentation for further details

8.13 E-Stop Drive Panel

This alarm indicates if the E-stop on the drive panel is activated. To reset twist the button until it comes out and then reset the system.

8.14 E-Stop Op Station

This alarm indicates if the E-Stop on the ground control Station (mounted on the decking) is activated. To reset twist the button until it comes out and then reset the system.

8.15 Disc Overtravel 1 & 2 Healthy

This alarm indicates if the two telescopic sensors on the top of the gimbal sheave have been tripped. If the balloon has been low moored it is quite common for these sensors to trip as the rope becomes slack If these sensors are tripped during normal operation this would indicate a malfunction of two other sensors so the ride should be stopped and David Brown contacted.

Note: Due to a slightly different configuration of these two switches, if only one switch is tripped the system will not reset until an E-stop button has been pressed to trip both E-stop channels.

8.16 Rope Overtravel Healthy

This alarm indicates if the rope overtravel switch has been activated. If the switch is activated there could be two possible reasons. The first one could be due to the operator not brining the disc down to the photo-eyes after each ride, resulting in an accumulative error over several rides. The second could be due to a system fault in the way the PLC calculates the ride height. Recover the ride using the emergency Key switch and ensure the disc comes right down to the photo-eyes, reset the system and ensure the ride height counters 1 & 2 are reading zero, if they do not reset contact David Brown. If they do reset attempt another ride with no passengers, check the height display as the ride ascends, if everything seems OK allow the ride to ascend to full height and check to see if the rope overtravel is actuated. If everything works OK try 4 rides monitoring closely, if everything still functions correctly record the event and continue the ride. If the ride continues to trip the sensor or abnormalities are noted as the winch pays out recover the balloon and contact David Brown.

8.17 Fleeting Sheave Overpayin Healthy

This alarm indicates if the fleeting sheave over-payin switch has been actuated, over many flights the position of the sheave can ‘drift’ a little, as long as the routine maintenance programme is followed the out of position of the sheave should be corrected before it gets close enough to trip the switch. If the switch should be tripped in will be necessary to low moor the balloon so the load is taken off the main cable and then manually wind the fleeting sheave off the switch until there is a 5mm gap between the switch and the side of the sheave.
If this switch should trip attention should also be made to the path of the rope ensuring that no contact has been made with the frame, if there has been contact the rope should be checked for damage.

8.18 Fleeting Sheave Overpayout Healthy

Under normal operating conditions this switch should never actuate as the rope overtravel switch should be tripped first. If this switch is actuated lower the ride on the emergency recovery key switch and check the position of the sheave at the bottom. If the sheave is a long way out of position try to ascertain why, if no reason can be found please contact David Brown for advice.

8.19 Count Impulse from Prox

This alarm indicates if there is an error in the method the winch uses to calculate the height of the balloon. This alarm will not stop operation but will warn the operator by activating the alarm buzzer and displaying the alarm on the display panel. It is unlikely that the site operators can rectify this fault, thus David Brown should be contacted for advice.

8.20 Count Proxy In Limits

This alarm indicates if there is an error in the method the winch uses to calculate the height of the balloon. This alarm will not stop operation but will warn the operator by activating the alarm buzzer and displaying the alarm on the display panel. It is unlikely that the site operators can rectify this fault, thus David Brown should be contacted for advice.

8.21 Drive Thermistor Healthy

This alarm indicates if the drive Thermistor (motor overtemp detector) is healthy. If the motor trips on overheat the ride should be recovered using the auxiliary motor and not the emergency recover key switch. The motor should never reach its overtemp state, as the invertor should trip the system on over torque before the motor overheats. If this alarm occurs recover the balloon on the auxiliary motor and contact David Brown.

8.22 Moor All. Push Button.

With the moor all / one toggle switch set on moor all this button will start all winches rotating in the direction set by the raise/lower toggle switch.
It must be ensured that all personnel are clear from the winches before operation, as it is quite often difficult to be in a position to see all winches 2 people should be used to assist the operator in mooring or de-mooring the balloon.

8.23 Power on Indicator Lamp.

This light indicates if the isolator on the mooring panel is on or off.

8.24 Reset / Motor Tripped Illuminated button on the mooring panel.

This button has 2 functions. Firstly when the mooring system has been switched on or after an emergency stop this button must be pressed to reset the system, as the button is pressed a ‘click’ will be heard from within the panel. Secondly if a motor should trip out due to overload or malfunction this light will illuminate, however all unaffected winches will operate normally.
Training on how to reset a tripped motor will be given to a representative on site, but due to the electrical hazard involved this manual does not describe this operation.
If in doubt contact the manufacturer for advice.