MORU Cardington Technical Note No. 2

Report on near failure of balloon flying cable on November 24th 1986

by

A.J.Lapworth

8 September 1992

Met. Office Research Unit
RAF Cardington
Shortstown
Beds, MK42 0TH

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Note

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1 Introduction

On the afternoon of 24th November 1986 an MRU balloon was flown at 3500 feet with six wind and temperature measuring probes clamped to the flying cable up to a height of 1900 feet. The balloon was a 24000 cubic foot Airborne MB24 flying on a 2·25 tonne cable. The winch in use was a statically mounted GQ type. A warm front had passed through earlier in the day and the surface winds were gusting to around 30 knots. After an initial data gathering run, during which the mean wind at 1900 feet was noted to be 37 knots, the balloon was pulled down 400 feet and a second run started. During the second run the wind on the top probe, then at 1500 feet, was seen to be increasing to a mean of about 40 knots with gusts to about 43 knots, and the decision was taken to haul down the balloon. The surface winds were by this time gusting to well over 30 knots. The cable tension during the second run had been fairly constant, with the winch tensiometer reading 2000 lbs. During the haul down, the reading on this tensiometer was observed to rise gradually until, with the balloon at around 2500 feet it surged twice to over 3000 lbs. It was afterwards discovered that during this initial part of the descent, individual strands had broken at a large number of points along the flying part of the cable. At this point one of the six main cable cores broke completely as is was passing over the winch capstan, and jammed the cable in the capstan. This was freed, and the partially severed cable was wound onto the drum, but within a few more turns a second break occurred. This was similar to the first and again took place in the cable running over the capstans. The winch was stopped and a carpenters stop used to secure the cable at the pulley block. A 16 ton lorry with a genny wheel was used to pull down the remaining cable, the probes, navigation lights, and drogues being removed at intervals. This report attempts to determine why the flying cable started to break up when the winch cab tensiometer only gave a stress at the surface of about 60% of the nominal breaking load of the cable, and how such a load occurred when the maximum gusts measured at the time were only 43 knots. The main factors considered were the cable itself, the winch, the balloon and the wind profile. Each item is considered in a one of the subsequent sections and conclusions on the probable causes of the near breakage summarized at the end. Since the results show that previous balloon operations have flown with the cable much closer to its breaking limits than was realised, the implications for future operations are discussed.

2 Cable

The cable in use was a KB3 specification (6 by 19) 2·25 tonne minimum breaking load cable It had been purchased within the previous two years and had only been wound on to the winch about a month previously. Test pieces cut from the terminator end on two occasions after winding on showed that where it had not passed over the capstans the cable broke at or above its minimum breaking load. (see Table 1(a)) It should be noted that on the static winch the 100 feet of cable nearest the terminator do not run through the winch and that the test pieces had not been through the capstan. The winch had been in daily use for the previous month and the cable had been through 30 reversals (one reversal consists of letting the balloon up to altitude and pulling it down again) It should be noted the normal practice in balloon flying is to discard the cable after 800 reversals. As was mentioned previously, after the incident the first 3000 feet of cable had numerous 'fish-hooks' along its length due to individual strands breaking. The two main partial breaks were at 2450 feet into the cable and the sections before and beyond them showed individual strands broken and 'fish-hooks' formed. Five test pieces were cut from various points along this 3000 foot length and tested to destruction by Anglia Handling at Biggleswade. The results are shown in Table 1(b). Two loadings are given for each test. These are the point at which 'pinging' was first heard and the final breaking point. The 'pinging' sound is believed to be due to the first strands breaking. In all the tests except one, the cable was held in self tightening clamps, and the cable broke at the clamps. In the first test, one end was held in a clamp, and one end with a loop and ferrule. This also broke at the clamp end. The tests summarized in Table 1(b) show that wherever the cable had run through the winch capstan, its breaking load had been reduced to 90load. It can also be seen that individual strands start to break within 15

However, none of the loads at which initial failure occurred are as low as the 1·4 tonnes recorded in the cab tensiometer at the time of failure. A calibration check was carried out on this instrument by comparing it against a PIAB tensiometer. The results are shown in Table 2. It can be seen that the cab tensiometer underreads by 500 lbs at 3100 lbs. This gives a corrected value of 1·6 tonnes at the winch end of the cable at the time of the incident. Calculations taking the cable and probe weight, and wind loading into account show that the tensions at the balloon end of the cable would have been 1·75 tonnes. Thus both ends of the cable would have been subject to loads at which initial failure of the cable might be expected from the test results.

In a test performed two years ago a similar cable had been used to perform 1000 reversals through a Rubery Owens winch with a load of around 600 lbs and test pieces taken afterwards had shown no diminution in strength (see Table 1(c)). Either the GQ winch is responsible for damaging the cable, or prolonged flying at higher cable tensions are the cause of the reduced strength. To test the later hypothesis, a similar cable used in a Rubery-Owens winch was tested. This cable had been through 70 reversals which included flying in some fairly high winds on a field detachment in Wales, when a gust load of about 1·5 tonnes was seen on the cab tensiometer. Test results on this cable prior to November 24th are shown in Table 1(d). Test pieces were cut from 100 feet of this cable near the terminator. It should be noted that on the mobile Rubery Owen winches, all except the first few feet of cable pass through the capstan. The test results are shown on Table 1(e). Half the test pieces were broken using clamps, and the other half using ferrules. The results appear to be independent of method used to grip the cable, and are similar to those obtained from the GQ cable. It seems likely therefore that the main factor involved in weakening the cable is the combination of high flying loads and running through the capstan. In this context it should be noted that British Ropes, the suppliers of the cable, state that all cables reduce in strength with time when loaded over 50

3 Winch

In the previous section it was shown that the cab tensiometer was at fault. However, a more important point is the question as to why the cable became partially severed twice at the capstan, when higher tensions existed higher up the cable. This was probably due to the additional stresses set up by bending the cable round the first roller on the capstan. Presumably the cable did not break completely because the load was in process of being transferred to the capstan. Two factors that may have contributed to the failure are the relatively small diameter of the GQ capstans and the 'V' grooves used. The ratio of cable diameter to capstan diameter is about 24:1 as distinct from about 35:1 for the Rubery Owens winch. The 24:1 ratio is considered by British Ropes to be near the lower limit of reasonable working, and ratios of 35:1 are prefered for lifts. Both winches use 'V' grooves as these grip the cable far better than the alternative 'U' grooves do However 'V' grooves are known to damage the cable to a greater extent than 'U' grooves. A compromise is a type of groove known as 'undercut U'.

It seems likely that the cable initially broke at individual strands and that the extra stresses induced by bending the cable over the capstan wheel caused an initially weaked point to break further. It is obviously important to allow for this effect when assessing loading limits in future, and not assume that the cable will neccessarily break at the point with the highest calculated loading. It seems probable, although not proven, that the cable might not have been so highly stressed on the larger diameter Rubery Owens capstans. It is also worth considering the use of capstans with 'undercut U' grooves.

4 Balloon

The observed increase in cable tension as the balloon was pulled down was caused by dynamic forces on the balloon. This could be due either to increased windspeed or to the increased lift and drag coefficients of a deformed or misoriented balloon. The balloon was already known to be suffering from a dynamic instability giving rise to a severe tail waggle in turbulent conditions, although this had not so far been found to cause increased drag. In addition, tests in 1985 in which balloon pitch was measured as a function of windspeed had shown that both the MB24 and the MB27 balloons had an alarming tendancy to pitch up in high winds. The Bateman balloons (HZA, Mk8, Mk10, Mk11 etc) all tend to a limiting pitch angle, and hence limiting lift and drag coefficient at high windspeeds. However the MB24 and MB27 have pitch angles that increase linearly with windspeed up to the highest windspeeds measured (44 knots for the MB24 and 35 knots for the MB27) The MB27 has a particularly large increase in pitch angle per unit increase in windspeed, but for both balloons there arises the possibility that pitch may increase in an unstable manner at windspeeds higher than those measured.

It was difficult to determine if any type of balloon instability was manifesting itself on this occasion. The balloon was not visible, and there is no direct measurement of windspeed in the height range of interest. The only check available is that of using data recorded during the second run, before the final descent. The windspeed at the height of the balloon during this run (3100 feet) can be inferred from measurements made by radiosonde ascents at 1800 hours from Crawley, Hemsby and Aughton. (Table 3) These indicate a probable wind of around 40 knots (range 36 to 44 knots) This also correlates with a probe measured wind of 40 gusting 43·5 knot wind at 1500 feet. Calculations made using previously measured pitch and lift and drag coefficients for the MB24 in a 42 knot wind at 3100 feet give a cable tension at the winch of 1·0 tonne, as observed (corrected reading). In addition the calculated cable angles are compared with the probe measured angles in Table 4. The calculation took wind drag on the cable and probes into account but not that due to drogues, or the weight of the lights. A static lift of 710 lbs (measured three days previously when the leakage was found to be 5 lbs per day) was used. It can be seen that the measured angles are within around 5° of the calculated angles, which gives reasonable grounds for assuming that prior to the final descent, the balloon did not have a drag significantly greater than that previously measured. If the pitch, lift and drag figures are extrapolated to windspeeds of around 50 knots, an estimation can be made of the windspeed required to cause the measured cable tensions at the winch during haul down. A mean wind of around 45 knots at 2500 feet, gusting to 48 knots is found to give the reported tensions, after taking into account corrections for tensiometer errors. In the next section it will be shown that such a windspeed possibly existed at this height. The minimum likely windspeed at 2500 feet was around 42 knots gusting 45 knots, and the difference between this windspeed and that calculated to cause the measured cable tensions is very small. It thus seems unlikely that the tensions were caused by a significant increase in balloon drag.

5 Windspeed Profile

In the previous section it was shown that an important factor in the increase in cable tension during the descent was the windspeed at 2500 feet. An important feature of the incident was the lack of wind measurements in the 1500 foot gap between the balloon and the top probe, coupled with a definite increase in windspeed during the second measurement run.

In this section a summary is given of the windspeed data available. The primary data is the probe data from the two measurement runs. (see Table 5) It can be seen that the mean windspeed between the two runs increased significantly. The 1500 foot windspeed during the second run became 42 knots towards the end of the run, gusting to over 44 knots.

The sodar data during these two runs is summarised in Table 6. Unfortunately, although it extends to the height of interest, it is obvious that at heights of over 1000 feet there is a systematic underreading of windspeed. This feature of underreading in high surface winds was also noted in the Wales detachment in Spring 1986.

The 1200, 1800 and 2400 ascents for the three nearest radiosonde stations are given in Table 3. The data indicates maximum mean winds of 44 knots at 3000 feet.

Finally there is the evidence of the balloon winch tensiometer, which as mentioned in the previous section would indicate a wind of 42 knots at 3100 feet, increasing to 45 knots, gusting to 48 knots at 2500 feet. It should be noted that the heights measured by the winch altimeter are correct to within a 100 feet, the loss of height due to cable lay-back being compensated for by a measured overreading of the altimeter by 12 percent. This is confimed by a comparison between probe heights measured by winch altimeter and by pressure sensor.

The wind measured by the cup anemometer on the 40 metre tower during this period is given in Table 7. At the time of the final descent it was 26 knots, gusting to 37 knots.

Thus the wind data is reasonably consistent apart from the inferred winds at 2500 feet which is 3-4 knots higher than might be expected. An important feature of the ascent profile shown in Table 8 is the inversion at 2000 feet. Previous work on wind profiles through inversions indicates that there is a possibility of a windspeed maximum (i.e. jet) in the 500 feet of stable air immediately above the inversion level. The reported steadiness of the cable tensions immediately prior to the final descent and the fact of obtaining sodar returns from up to 2500 feet both indicate stable air at these heights.

It is thus possible that the jet inferred from the cable tensions really did exist. Another possibility is a transient increase in windspeed immediately above the inversion related to updraughts in the boundary layer.

An important point is the extremely small margin that exists between operating windseeds and windspeeds that break the cable. Prior to this incident it had been estimated that the cable might break at 53 knots. Allowing for the previously mentioned cable weaknesses, the estimated windspeed at failure was around 48 knots. In the windspeed region of 40-50 knots THE CABLE TENSION INCREASES BY ABOUT 0·1 TONNE (220 LBS) FOR EVERY 1 KNOT INCREASE IN WINDSPEED. A gust of 5 knots will add half a tonne to the tension. It is thus important to recognise that the adopted wind limits are gust limits, i.e. the maximum mean wind allowable should be of order 5 knots below the limits. It is also important to ensure that when operating close to the limits, that the windspeed does not gust above the limit at any height, as the balloon will have to pass through all levels on descent. One of the major problems with the present balloon is that its pitch increases linearly with windspeed, and hence the cable tension increases as the cube of the windspeed.

6 Conclusions

The main factors, ignorance of which resulted in the partial severance of the flying cable are as follows:

(a) A degradation in cable strength of 10% due to operating at tensions of order 50%of the minimum breaking load.

(b) Previously unrecognised failure of individual strands at 80 percent of the minimum breaking load.

(c) Additional stresses placed on the flying cable when bending round a winch capstan and probably aggravated by the small radius of the capstan in use.

(d) The underreading of the uncalibrated winch tensiometer.

(e) The existence of an undetected wind jet above a temperature inversion with a windspeed excess of 4 knots.

7 Recommendations

The conclusions of this report, summarised in the previous section, indicate that some changes in flying procedure are neccessary if a future balloon breakaway is to be avoided. The three areas in which change in flying practice should be made are those of winches, cable inspection, and windspeed limits. The following proposals are suggested:

(a) Cable test pieces should be made from cable that is known to have passed through the capstans.

(b) Cable tests should be made every 20 reversals when the cable is known to have been stressed in excess of 30 percent of its minimum breaking load (i.e. 15cwt for KB3).

(c) Cab tensiometers should be calibrated annually

(d) The Rubery Owens winch with its larger diameter capstans should always be used in preference for strong wind flying.

(e) The possibility of using 'undercut U' groove capstans should be investigated.

(f) The windspeed limits on flying should be reduced to take account of the weaknesses that are now known to exist in the system. If we take a factor of 2·5 on the strain known to have caused partial severance on the cable (i.e. 1·6 tonnes), a windspeed limit of 30 knots is obtained. This should be taken as a gust limit - that is the balloon should not be flown when the windspeed is known to be gusting above 30 knots at any level. This is 6 knots below the previously determined limit of 36 knots (raised to 38 knots for the Welsh detachment).

(g) When operating close to the windspeed limits, and especially if for some reason it is decided to exceed them, a probe should always be flown in the region of maximum windspeed.

8 Addendum

In the month after the original report on this incident was completed, some trials were carried out to determine the effect of continuous high loads on the strength of a balloon tether cable, and whether the type of groove used on the winch capstans affected the point of ultimate failure. The cable, type KB65, was run from the winch over a pulley held by a crane jib and terminated in an adjustable load. After setting the load, the load was raised and lowered continuously until either 50 reversals had been completed or the cable started to break up, which invariably took place where it ran over the capstans. Three pieces were then cut from the cable - the first near the terminator, the second near the crane block, and the third just before the surge drums. These cable pieces were then tested and the breaking loads are given in the tables below. The results were as follows:

FRESH UNTESTED CABLE FROM THE DRUM:	Started to break (tonnes)	Failure (tonnes)
	2·90	3·28

The first series of tests used a well used flying cable that had previously experienced a load of 1·1 tonnes when the balloon had been flying at 2000 feet.

USING 'V' GROOVES AND 32 CWT LOAD: Broke up on winch after 19 reversals.

Position	Started to break (tonnes)	Failure (tonnes)
Terminator		3·27
Crane block		3·26
Surge drums	2·98	3·22
	3·39	3·48

USING 'V' GROOVES AND 20 CWT LOAD: Did not break up on winch after 50 reversals.

USING 'V' GROOVES AND 25 CWT LOAD: Did not break up on winch after 50 reversals.

USING 'V' GROOVES AND 32 CWT LOAD: Started to break up on winch after 13 reversals.

USING UNDERCUT 'U' GROOVES AND 20 CWT LOAD: Did not break up on winch after 50 reversals.

Position	Started to break (tonnes)	Failure (tonnes)
Terminator		3·58
Crane block	3·3	3·4
Surge drums		3·6

USING UNDERCUT 'U' GROOVES AND 25 CWT LOAD: Did not break up on winch after 50 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·47	3·5
Crane block		3·69
Surge drums	3·4	3·65

USING UNDERCUT 'U' GROOVES AND 32.5 CWT LOAD: Did not break up on winch after 50 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	2·99	3·22
Crane block	3·4	3·45
Surge drums	3·7	3·7

USING UNDERCUT 'U' GROOVES AND 38 CWT LOAD: Did not break up on winch after 50 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·49	3·56
Crane block	3·5	3·59
Surge drums	3·1	3·39

USING UNDERCUT 'U' GROOVES AND 43 CWT LOAD: Started to break up on winch after 28 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·2	3·3
Crane block	3·1	3·3
Surge drums	2·9	3·48

For the next series of tests, 2000 feet of cable was removed from the winch, so that fresh, unused cable was tested:

USING 'V' GROOVES AND 20 CWT LOAD: Did not break up on winch after 50 reversals.

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·4	3·58
Crane block	3·3	3·4
Surge drums	3·3	3·49

USING 'V' GROOVES AND 25 CWT LOAD: Did not break up on winch after 50 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·2	3·4
Crane block	3·48	3·69
Surge drums	3·2	3·2

USING 'V' GROOVES AND 32.5 CWT LOAD: Started to break up on winch after 13 reversals

Position	Started to break (tonnes)	Failure (tonnes)
Terminator	3·2	3·4
Crane block	3·48	3·69
Surge drums	3·2	3·29

From these results it will be seen that under continuous high load, a cable will start to break up on the capstans, if nowhere else, at about 1/2 of its minimum breaking load using 'V' grooves and 2/3 of its minimum breaking load using undercut 'U' grooves. Pure 'U' grooves were not tested, but this type of groove was in use on the GQ winch at the time of the incident, and has been seen, breaking up occured at 7/10 of its minimum breaking load - a figure remarkably close to the 2/3 for undercut 'U' grooves on KB65, especially when it is seen that this was for no reversals, and that for 10 or so reversals the failure load would have been slightly lower.

The significance of this is that in future, the calculation of all safe loads must start from the premise that the cable will break at 2/3 of its MBL at the capstans (for 'U' grooves) rather than at its MBL by the terminator except in the few cases where the latter figure is lower. This does not seem to have been realised by RAE in its final days, although there is a possibility that it was known to the people that originally calculated the safe working limits of the balloons and was incorporated into the safety factor of 2·5 or 3·0 used by them in relation to the MBL of the cable. This seems more plausible when the results taken from the 1989 Caersws field detachments are considered. These showed that for an MB24A balloon flying in a wind of 30 knots, gusting 35 knots, non equilibrium (shock) loads measured at the terminator could be at least a factor of 1·5 up of the equilibrium (static plus dynamic) loads for a given instantaneous windspeed. Thus if the two factors of reduced cable strength and non-equilibrium loads are taken into accoount, a factor of 2·3 (3·0 for 'V' grooves) is derived, close to the 2·5 used. The conclusion is that the 2·5 is NOT A SAFETY FACTOR but a realistic appraisal of the actual failure limits of the balloon cable.

It should be noted that a quoted wind limit using the 2·5 factor must be seen as a limit on gusts rather than mean winds as there is no allowance in the above for any further gust factor. Gusts at an altitude may be of order 10 percent of the mean wind, although close to the ground they are of order 50 percent or more and may vary greatly in direction.

Since the above incident, a new balloon (the MB24A) has been procured. This has larger fins of the Mark 8 type. These do not suffer from the rudder waggle of the MB24 rudder, but also appear from the above-mentioned Caersws trials to limit the pitch of the balloon, although more work on this needs to be done. If this is confirmed, it will support the idea that the reason for the extreme pitch of the MB24 and MB27 balloons was the small length of the fins which did not extend beyond the turbulent region immediately to the rear of the maximum balloon diameter and hence were not effective in lifting the rear of the balloon as the wind increased. The Mk 8 fins were longer and protruded well outside the maximum balloon diameter.

Table 1.

Results of flying cable tests (figures in tonnes).

(a) Cable on GQ winch prior to November 24th.

Initial Failure	Final Break	Comment
	2·2	after reeving on 14.11.86
	2·4	(10 reversals)

(b) KB3 cable on GQ winch after November 24th.

Initial Failure	Final Break	Comment
2·08	2·25	at terminator
1·79	2·09	250 feet from terminator
1·60	2·06	1500 feet from terminator
1·68	1·94	2300 feet from terminator
1·64	1·94	2500 feet from terminator

(c) KB3 cable on Rubery Owens in 1984 after 1000 reversals and 600 lbs load.

Initial Failure	Final Break	Comments
	2·4	Before test
	2·3	After test
	2·24	After test

(d) KB3 cable on Rubery Owens prior to November 24th.

Initial Failure	Final Break	Comment
	2·28	after reeving on
	2·23	$7\frac{1}{2}$ months later (76 reversals)

(e) KB3 cable on Rubery Owens after November 24th.

Initial Failure	Final Break	Comments
1·59	2·05	tested next to terminator
1·79	2·03	50 feet in 1.12.86 (clamps)
1·98	2·15	50 feet in 2.12.86 (ferrules)
1·60	1·85	50 feet in 2.12.86 (")
1·65	1·94	50 feet in 2.12.86 (")

Table 2.

Calibration of GQ tensiometer against PIAB readings in pounds force.

GQ	PIABS
0	0
2000	2200
3100	3600
1950	2100
0	0
3100	3600
0	0

Table 3.

Winds from radiosonde stations on November 24th. (in degree/knots).

Heights in feet

Time	Hemsby	Crawley	Aughton
1200Z	3000 280/36 5000 290/41	3000 275/37 5000 280/37	3000 260/37 5000 265/35
1800Z	0 240/16 3000 265/44 3300 272/41 4000 278/36 5000 275/35	0 230/12 1000 245/28 3000 265/38 4000 270/43 6000 285/34	0 200/12 3000 230/36 5000 260/45
2400Z	3000 270/50 5000 270/54	3000 250/40 5000 240/43	3000 240/40 5000 250/50

Table 4.

Calculated cable angles versus measured angles.

Readings in degrees			Heights in feet
First Run:	Height	Measured Angle	Calculated Angle
	1934	27	24
	1433	30	26
	1038	32	27
	752	35	28
	595	35	29
	583	38	29

Second Run:	Height	Measured Angle	Calculated Angle
	1560	26	24
	1050	30	26
	650	31	27
	350	33	28
	200	34	28
	100	36	28

Table 5.

Probe: Windspeed in knots.
Heights are in feet.

First Run (15·07 - 16·19)

Height	Windspeed
1934	37·5
1433	36·7
1038	33·6
752	31·6
595	29·5
583	28·5

Second Run (16·29 - 17·41)

Height	Windspeed
1560	39·5 (gusts 44·4 later)
1050	36·4
650	31·6
350	29·0
200	26·0
100	24·0

Table 6.

Sodar Winds - Windspeed in knots.
Heights in feet.

Times	1530	1600	1630	1700	1730	1800
Height						
2690						
2560	35				34	
2430					35·7	
2300				30·5	33	26·7
2170		20				
2030		29·3	15·5		35·1	
1900		17·8		36·1		35·3
1770	34·8	33·7		35·3	40·5	
1640	35·3	31·1		34·2	35·1	
1510				33·5		41·5
1380	21·8	34·6	35·7	53·8	21·8	
1250	32·7	33·9	36·3	33·4	31·4	30·7
1110	30·8	26·3		33·9	37·7	36·9
980	31·9	33·8	35·8	34·6	40·2	35·8
850		32·5	32·6	34·7	34·1	36·9
720	30·8	26·0	30·0	30·6	35·4	32·8
590	28·8	23·8	29·4	27·6		32·6
460	27·0	28·5	20·9	29·3	31·0	32·2
330	24·5	25·0	25·2	27·6	30·9	29·9
200	22·7	27·3	23·9	17·7	27·9	29·3
30						
10						

Table 7.

Surface windspeed in knots taken from 40m tower.

Time	Mean	Gust
1600	24	33
1630	23	32
1700	26	35
1730	28	37
1800	26	34
1830	26	34

Table 8.

Potential temperature profile at 1400.

Temperature in °C.

Height in feet.

Height	Temperature
1800	14·8
1600	14·3
1400	13·9
1200	13·6
1000	13·4
800	13·4
600	13·3
400	13·1
200	12·9
0	12·5