Coltique cc
CK98/45353/23
Maintenance Solutions

Technical Report

[redacted]

Report Date: 6 June 2008

Customer Company: [redacted]

Client Responsible person:

Site:

Executive Summary
• Fire was ignited by electrical cable.
• Fuel lines next to cables aggravated the damage.

Vehicle Detail

Registration Number:	[redacted]
VIN:	
Chassis Make:	Mercedes Benz
Chassis Model:	OF2429
Body Make:	Marcopolo
Fleet Number:	[redacted]
Distance Reading:	Unknown

Inspector Detail

Inspector:	D Brand (N.Dip. Eng. Mech)
Cell phone Number:	082 773 9832
Fax Number:	086 514 3948
E mail address:	coltique@absamail.co.za

Client Detail

Inspection date:	27, 28 & 30 May 2008
Contact Person:	[redacted]
Contact Telephone Number:	
Contact Fax Number:	
Contact E mail:	
Address:	
City (Site Location)	
Nature of Business	Passenger Transport
Observer Name:	[redacted]

Date	
Signature	

Inspection Introduction

Vehicle [redacted] was involved in an incident where the vehicle caught fire.
The purpose of the investigation is to highlight any possible ignition points that could have started the fire.

1) Incident Detail

Information given to the writer in connection with the location of the incident is as follows:

Midlands / Pietermaritzburg
Vehicle stopped before the town to change drivers.
The driver stopped the vehicle after 2 km drive time.

2) Scope of Inspection

The investigation included the front brake system and electrical equipment.
These included:

Batteries
Starter-motor
Alternator
Cables & Fuses
Telma Retarder

3) Method of Inspection

A visual inspection was carried out on all parts in the scope of the investigation.
None of the parts was removed or cleaned for the inspection. The vehicle was on a pit in the workshop for this investigation. The damage was confined to the front of the vehicle and thus the back was not inspected.

Observations

1) Batteries

Heat damage (melted plastic) was visible on the batteries.
The batteries were structurally intact.
The retarder control box was melted to the front battery.
The battery terminals was melted (lead terminals)

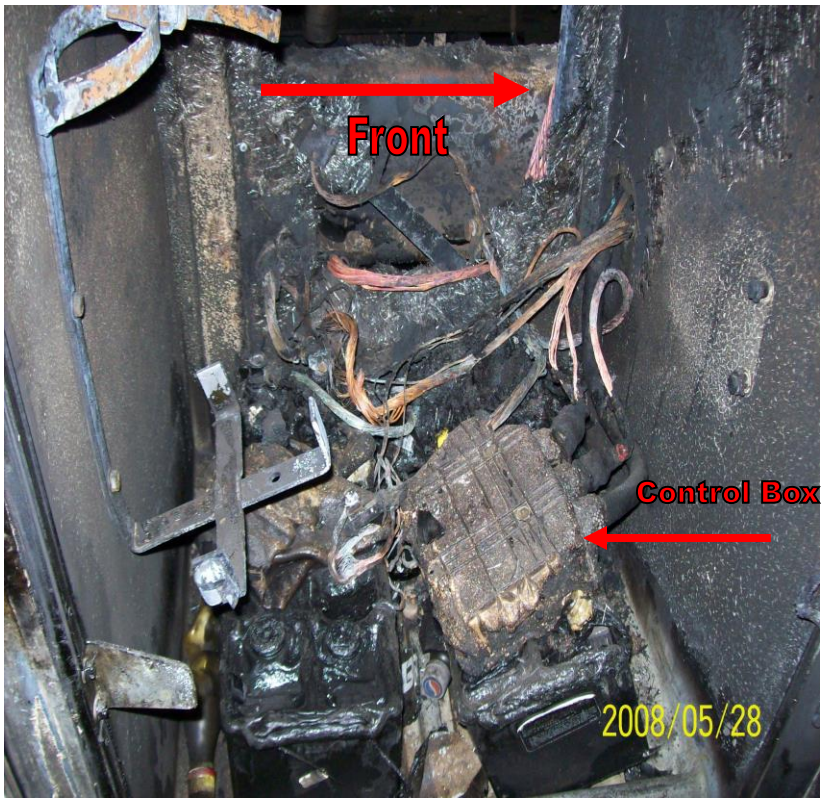


Photo 1

Photo 2

2) Starter-motor

The electrical connections to the starter-motor was intact and without fire damage.

Photo 3

3) Alternator

No fire damage was observed at the front of the engine compartment. The alternator was thus not suspected of any damage.

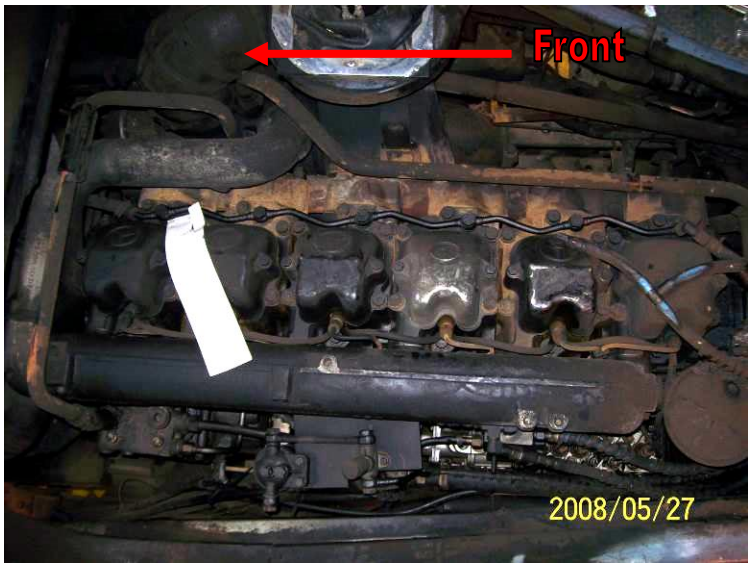


Photo 4

4) Cables & Fuses

No heat sleeving was observed for the cabling and piping next to the retarder.

<u>Positive starter-motor (terminal 30) cable.</u>
The cable was welded to a cross member beam.
Insulation was missing between battery terminal (30) and cross member

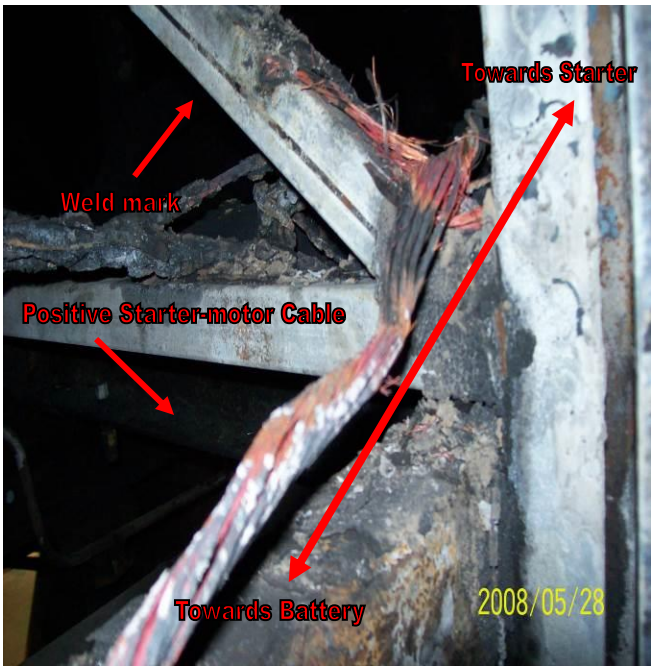


Photo 5

Insulation was intact between starter-motor and cross member

Positive cables (4 stages) to Retarder
The cables were intact.
Fire damage was observed on insulation.

Earth cable retarder
The cable was intact.
Shaving damage was observed corresponding to the retarder rotor.
All insulation was gone except a section corresponding to the retarder rotor area.

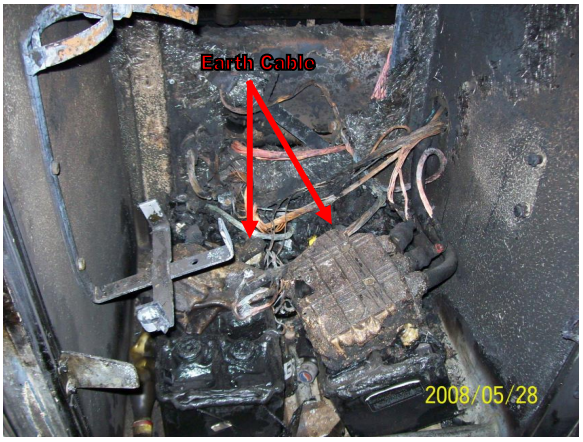


Photo 6

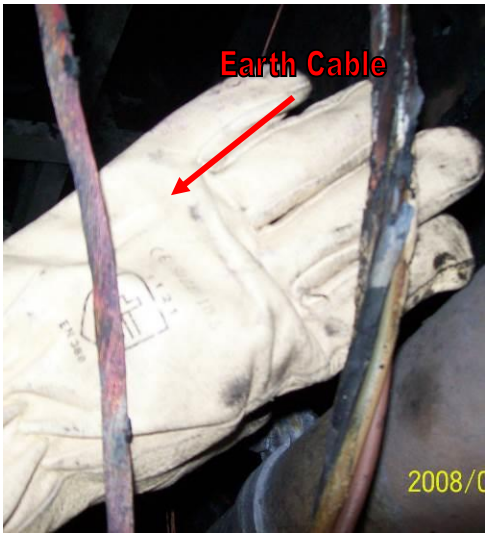


Photo 7

Main blade fuses
No evidence of foreign objects was observed in the fuse holders (Bridging wire etc)

5) Telma Retarder

The earth terminal was found loose on the retarder.

Photo 8

Photo 9

Arcing marks was found on the rotor of the retarder. Corresponding damage was found on the earth cable

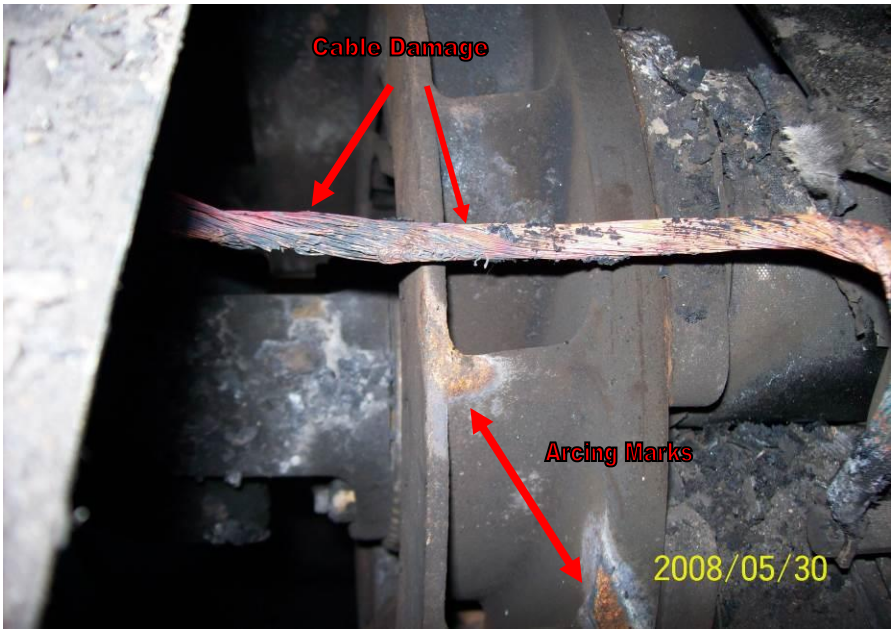


Photo 10

6) General

The area of the most intense heat was found in the area between the gearbox and retarder.

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16

Photo 17

Photo 18

Photo 19

Photo 20

Photo 21

Photo 22

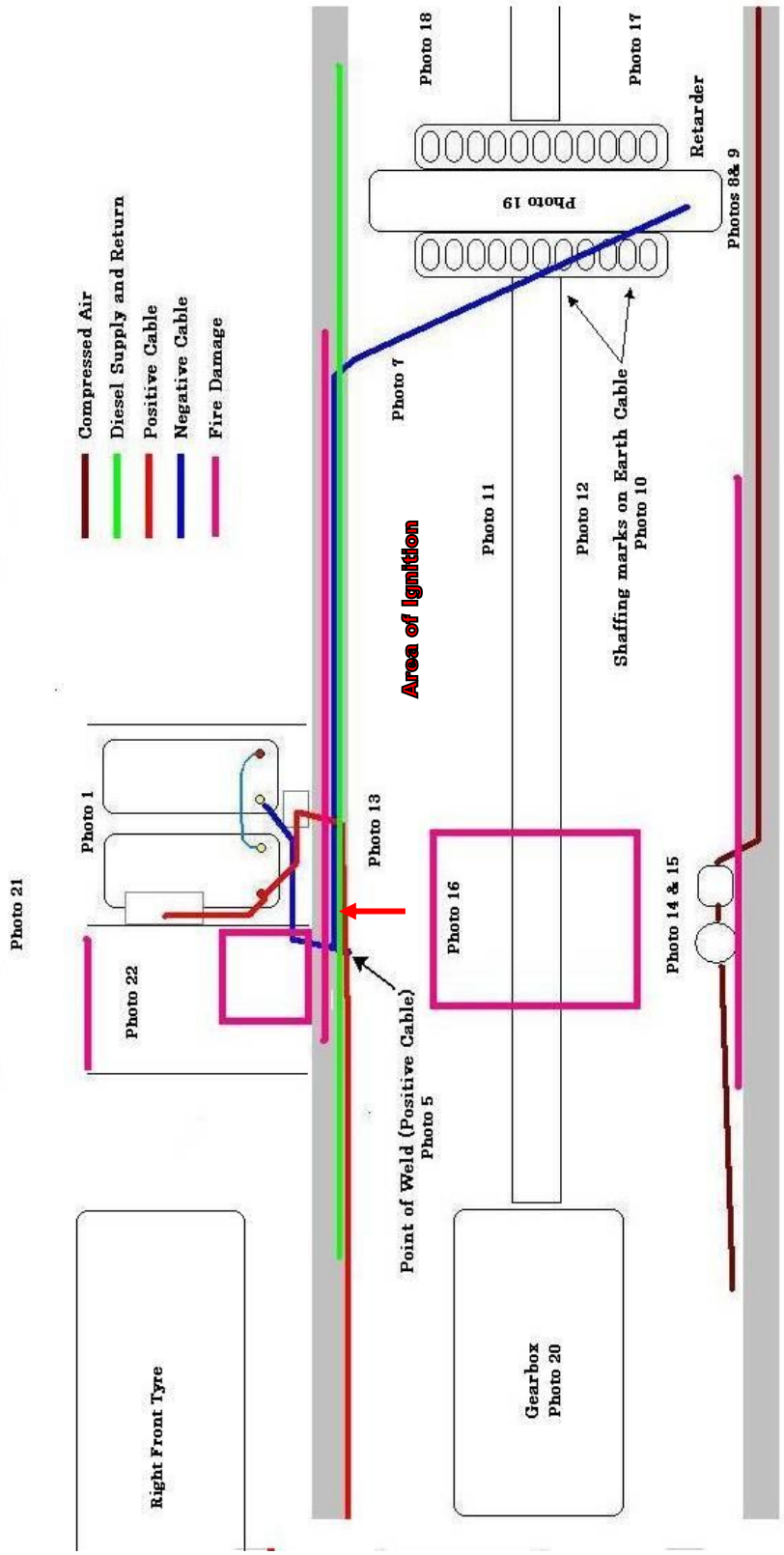


Diagram 1 (Not to scale)

Analysis (Retarder Earth Cable)

1) Specifications

The retarder fitted to the vehicle is a Telma AC 61-60.
This retarder works by electro-magnetic force. It heats up as it retards the vehicle.
This heat is dissipated to the air steam.
The retarder has four stages with the highest current draw at 127 Amp according to manufacturer's specifications.

Stage Cables	6	AWG	Insulation PVC-FLY
Diameter	4.11	mm	
Sectional Area	13.29	mm²	
Cable used (ISO6722)	16	mm²	
Earth Cable	00	AWG	Insulation PVC-FLY
Diameter	9.27	mm	
Sectional Area	67.4	mm²	
Cable used (ISO6722)	70	mm²	
Resistance per Stage (Coil)	0.75	Ω	@ 20ºC
Current per stage (I)	31.5	A	@ 20ºC
System Voltage (Uvl)	24	V	
Estimate cable length (l)	2	m	
Specific electrical resistance of Copper	0.0185	Ω.mm²/m	

Cables, specified to ISO 6722 (FLY) standard, and are used in this application. To comply with this standard the insulation must be stable between -25ºC and +90ºC (For continuous 3000 hours). The insulation is fuel and oil resistant. It is however not resistant to detergents.

2) Calculations

The critical section (in terms of fire hazard) of the retarder is the earth cable.
The resistance of the cable increases as the cable corrodes.

Resistance	Current	Voltage Drop	Heat Loss (Specification)	Heat Dissipation	Energy/Power Available
Earth Cable	System	Earth Cable	Earth Cable	Earth Cable	Retarder
mΩ	A	V	%	mW/mm²	%
0.529	127.2	0.067	100	88	100
5.329	124.1	0.661	**959**	843	**95.1**
10.729	120.7	1.295	1827	1605	90
16.729	117.2	1.960	2684	2359	84.8

The calculations show that the retarder would be operating with only 5% efficiency loss while the earth cable is heating up to dangerous levels.

3) Physical Evidence

Two factors support the high resistance earth cable scenario.

3.1 Lack of insulation. The lack of insulation on the cable (not only in the centre) could indicate that the insulation was at elevated temperature for an extended period.

3.2 Arc marks on retarder. This indicates that the resistance through the retarder, gearbox, chassis and battery was less than through the Retarder Earth Cable.

4) OEM Maintenance procedures

The OEM (Telma, VALEO Electrical) has issued Maintenance Procedures specific to this problem.

4.1 TIL03005 (Amperage check procedure) – 4 Oct 1997

The procedure is scheduled for every 60 000 km.

4.2 TIL03006 (Resistance check procedure) – 4 Oct 1997

The procedure is scheduled for commissioning only

These procedures are however not very well known in the South African industry.

Findings

1) Point of ignition

The exact point of ignition cannot be determined. It appears however if the ignition point was behind the battery box in the chassis beam. (Close to the point of arcing/weld between the positive starter-motor cable and chassis)

2) Cause of ignition

Two possible causes of ignition were found.

2.1 Positive starter-motor cable chaffed through on chassis beam. This caused arcing and a very high heat condition. This cable cannot be fuse protected. This arcing would continue until the battery stopped supplying power or the cable burnt through.

2.2 The Retarder Earth cable heated up due to resistance build-up. This caused degradation of insulation. Next to the Earth cable was fuel lines and positive cables.

3) Aggravating circumstances

In both scenarios the spread of the fire was aggravated by two factors.

3.1 Diesel lines, both supply and return, was strapped to the electrical cables.

3.2 After the compressed air line on the opposite side chassis beam started leaking it increased air flow to the fire.

Recommendation

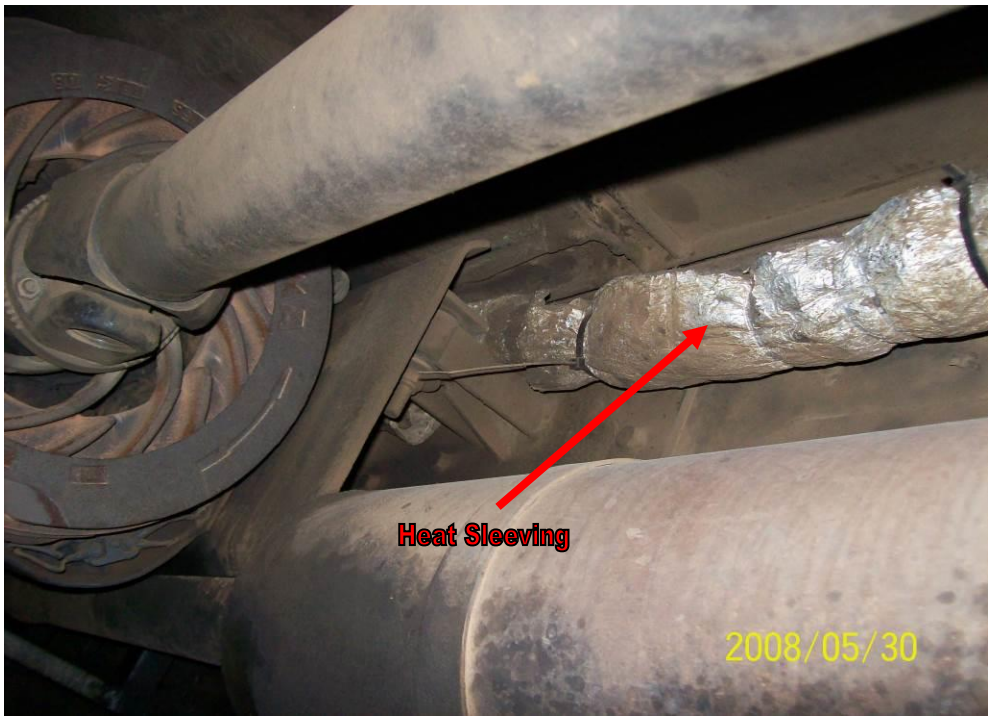
Maintenance

1) It is recommended that the OEM maintenance procedures be followed at the scheduled intervals.

2) It is recommended that all electrical cables be separated from fuel lines as far as possible.

3) It is recommended that all electrical cables (> 8.5 mm^2), in and around the chassis, be replaced at 1 000 000 km interval irrespective of condition.

4) It is recommended that all electrical and fuel lines be placed in heat sleeving in the vicinity of a Telma Retarder. This can be extended to 0.5 m on both sides on the retarder.



Appendix A

Calculations

Resistance of Stage Cable	0.0023125	Ω	
Resistance of Cable (4 Stages)	0.000578125	Ω	
Resistance of Earth Cable	0.000528571	Ω	
Resistance of Coils (4 Stages)	0.187500	Ω	
Total Resistance of Circuit	0.188606696	Ω	As new Specification
Total Current (Calculated)	127	A	
Energy Loss (Stage Cables)	9	W	
Energy Loss (Earth Cable)	9	W	
Energy Loss (Single Coil)	759	W	
Total Energy Loss	3054	W	
Current Density (Stage Cable)	2.0	A/mm²	As new Specification
Current Density (Earth Cable)	1.8	A/mm²	As new Specification
Increase in Earth Cable Resistance	0.0006	Ω	Increments
Diameter Conductor (Earth Cable)	12.5	mm	
Outer Area Conductor (Earth Cable)	0.079	m²	
Diameter Insulation (Earth Cable)	15.5	mm	
Outer Area Insulation (Earth Cable)	0.097	m²	
Insulation thickness (Earth Cable)	1.5	mm	
Volume of Insulation	131947	mm³	

Resistance Earth Cable	Resistance System	Current System	Voltage Drop Earth Cable	Energy Loss Earth Cable	Energy Loss Earth Cable	Energy Dissipation per mm² of insulation	Energy Available Retarder	Energy Available Retarder
Ω	Ω	A	V	W	%	mW/mm²	W	%
0.000529	0.188607	127.2	0.067	9	100%	88	3036	100.0%
0.001129	0.189207	126.8	0.143	18	212%	186	3017	99.4%
0.001729	0.189807	126.4	0.219	28	323%	284	2998	98.7%
0.002329	0.190407	126.0	0.294	37	432%	380	2979	98.1%
0.002929	0.191007	125.7	0.368	46	540%	475	2960	97.5%
0.003529	0.191607	125.3	0.442	55	647%	568	2942	96.9%
0.004129	0.192207	124.9	0.516	64	752%	661	2923	96.3%
0.004729	0.192807	124.5	0.589	73	856%	752	2905	95.7%
0.005329	0.193407	124.1	0.661	82	959%	843	2887	95.1%
0.005929	0.194007	123.7	0.733	91	1060%	932	2869	94.5%
0.006529	0.194607	123.3	0.805	99	1160%	1020	2852	93.9%
0.007129	0.195207	122.9	0.876	108	1259%	1106	2834	93.4%
0.007729	0.195807	122.6	0.947	116	1357%	1192	2817	92.8%
0.008329	0.196407	122.2	1.018	124	1453%	1277	2800	92.2%
0.008929	0.197007	121.8	1.088	133	1548%	1361	2783	91.7%
0.009529	0.197607	121.5	1.157	141	1642%	1443	2766	91.1%
0.010129	0.198207	121.1	1.226	149	1735%	1525	2749	90.5%
0.010729	0.198807	120.7	1.295	156	1827%	1605	2733	90.0%
0.011329	0.199407	120.4	1.363	164	1917%	1685	2716	89.5%
0.011929	0.200007	120.0	1.431	172	2007%	1764	2700	88.9%
0.012529	0.200607	119.6	1.499	179	2095%	1841	2684	88.4%
0.013129	0.201207	119.3	1.566	187	2182%	1918	2668	87.9%
0.013729	0.201807	118.9	1.633	194	2269%	1994	2652	87.3%
0.014329	0.202407	118.6	1.699	201	2354%	2069	2636	86.8%
0.014929	0.203007	118.2	1.765	209	2438%	2142	2621	86.3%
0.015529	0.203607	117.9	1.830	216	2521%	2215	2605	85.8%
0.016129	0.204207	117.5	1.896	223	2603%	2288	2590	85.3%
0.016729	0.204807	117.2	1.960	230	2684%	2359	2575	84.8%