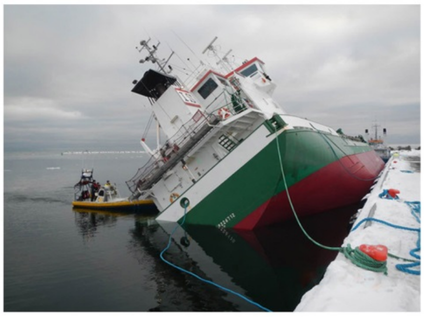
Statens haverikommission
Swedish Accident Investigation Authority



Final report RS 2017:06e

ZJAWA IV - grounding on 5 December 2016, at Falsterborev, Skåne county, Sweden

File no. S-203/16

1 December 2017

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se
ISSN 1400-5735
This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

Postadress/Postal address	*Besöksadress/Visitors*	*Telefon/Phone*	*Fax/Facsimile*	*E-post/E-mail*	*Internet*
P.O. Box 6014 SE-102 31 Stockholm Sweden	Sveavägen 151 Stockholm	+46 8 508 862 00	+46 8 508 862 90	info@havkom.se	www.havkom.se

Statens haverikommission
Swedish Accident Investigation Authority

Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

The investigation

SHK was informed on 5 December 2016 that a marine casualty involving the Polish motor sailing vessel ZJAWA IV, SQMS, had occurred the same day at 14.00 hrs.

The accident has been investigated by SHK represented by Ms Helene Arango Magnusson, Chairperson, Capt. Jörgen Zachau, Investigator in Charge, Capt. Dennis Dahlberg, Operations Investigator, and Mr Alexander Hurtig, Investigator Behavioural Science.

The investigation team of SHK has engaged SG GolfCon, which in cooperation with the Swedish Compass Adjusters Association has performed a technical investigation of a magnetic compass. Kalmar Maritime Academy has assisted in the interpretation of the investigation result. The Polish State Marine Accident Investigation Commission has assisted with interpretations and Polish contacts.

The investigation was followed by Mr Fredrik Tyrén of the Swedish Coast Guard, Mr Ulf Holmgren of the Swedish Maritime Administration and Capt. Patrik Jönsson of the Swedish Transport Agency.

Investigation material
Interviews have been conducted with crew members, former crew members and with the person ashore with a designated responsibility (DPA) of the company. The vessel has been investigated by SHK. Information has been collected from the flag state, Maritime Office Gdynia, and the classification society Polski Rejestr Statków, PRS.

Final report RS 2017:06**e**

Ship particulars	
Flag/register	Poland
Identification	
IMO identification/call sign	-/SQMS
Vessel data	
Type of ship	Motor-powered sailing vessel
New building shipyard/year	Unknown shipyard in Sweden/1949 and 1983
Gross tonnage	43.70
Length, over all	20.90 m
Beam	5.64 m
Draft	Approx. 2.5 m
Main engine, output	Engine replaced in 2016, former 105 kW
Propulsion arrangement	Sail and propeller
Lateral thruster	No
Rudder arrangement	Conventional
Ownership and operation	Maritime Education Centre of Polish Scouting and Guiding Association
Classification society	PRS
Minimum safe manning	3

Voyage particulars	
Ports of call	Peterhead, Scotland – Gdynia, Poland, via Kristiansand, Norway, and Gothenburg, Sweden
Type of voyage	International
Manning	9

Marine casualty information	
Type of marine casualty	Very serious
Date and time	5 December 2016 approx. 14:00 hrs
Position and location	N55° 21.02′ E012° 48.2′ Falsterborev
Weather conditions	W 10–13 m/s, good visibility
Other factors	Current 0.3 knots eastbound
Consequences	
Personal injuries	None
Environment	None
Vessel	Substantial damage

Figure 1. ZJAWA IV. Image: Maritime Education Centre of Polish Scouting and Guiding Association.

SUMMARY

ZJAWA IV was crossing the Atlantic, bound for her home port Gdynia, Poland. During the voyage, a longer stop was made in Peterhead, Scotland, for maintenance and engine replacement. Before departure, discussions between the master and the ship's owner resulted in the master and a couple of crew members returning home at their own expense. The reason was that those returning home did not consider the vessel being suitable for crossing the North Sea at this time of the year. The owner sent replacements.

The voyage commenced though the heating system as well as the stove was not in working order. Furthermore the vessel leaked and had to be drained every now and then. The weather was at times harsh and the vessel therefore had to seek port to await better weather conditions. During the voyage, the crew's diet was poor and prepared only with hot water.

As the vessel had passed Drogden light house and the main part of the Sound, the master handed over the watch to the officer, who was instructed to turn port and eastwards after passage of Falsterborev. The officer instructed the helmsman, one of the two lookouts, to go closer to land, i.e. more to the east, to avoid heavy traffic in the traffic lanes, to reduce work with the sails. The officer was on occasion busy draining water from the engine room.

At 13:48 5 December, the vessel touched ground on the shoals of Falsterborev, closely south of Måkläppen. The crew was evacuated some hours later. Any injuries did not occur, though the vessel had sustained substantial damage.

For navigation an electronic chart in the master's private computer was used. As there was no functioning compass available, the computer and GPS information was used to establish the course. Both the GPS:s and the computer were in the chart room, one deck below the conning place.

The grounding was caused by the vessel being navigated on a route that was supposed to be safe, without the position being controlled with an alternative navigational method. Drift, caused by wind and current, may have brought the vessel closer to the shallow area than expected. Contributing is most likely that the officer partly paid attention to other duties below deck. Further, it cannot be ruled out that the area Falsterborev and the lighthouse Falsterborev may have been confused with each other, contributing to the vessel being brought into the shallow area.

Poor preconditions with poor diet and damp, cold conditions have most likely affected the planning and performance of the voyage negatively.

Safety recommendations

As the company has taken relevant and adequate action, SHK refrains from issuing any recommendation (see section 4).

The Polish Flag State Authority is recommended to:

- complement its inspection procedures to make them better embracing control of function and use of magnetic compasses (see section 2.4). (*RS 2017:06 R1)*

1. FACTUAL INFORMATION

1.1 Sequence of events

ZJAWA IV crossed the Atlantic, bound for her home port Gdynia, Poland, where she had not been for some time. During the voyage, a longer stop was made in Peterhead, Scotland, for maintenance and engine replacement. During the stay, discussions were raised between the master and the owner's representative about the suitability of continuing the voyage at the current time of year in the state the vessel was in (see section 1.4). The discussion ended with the master and some other crew members returning home at their own expense, while the ship owner sent replacements.

After the vessel departed Peterhead with some new crew members, the weather deteriorated, and the vessel therefore headed for Kristiansand, Norway, to await better weather conditions. As problems with the electricity had occurred, the vessel thereafter went to Gothenburg, Sweden, to have an electrician, who then accompanied the vessel, taken on board. The vessel stayed in Gothenburg for two nights, and bunkering took place.

On 5 December, at 12:00 hrs, there was a change of watch. The master, who had been on double watch as they passed Drogden fairway, had thus been on watch for 6–7 hours. The change occurred right after passage through the fairway and the lighthouse Drogden, which had been passed on port side after course 170° had been held.

The master handed over the watch to the navigation officer. Also the two lookouts (whose watchkeeping alternated between being helmsman and lookout) were changed. The relief consisted in the officer receiving the instruction to turn to port after passage of Falsterborev, which was to be passed on the western side. In the electronic chart in the master's computer there was a planned course laid off to take the vessel through the fairway to Falsterborev. The sails set at this moment were mainsail and another sail on the forward mast. The engine was running half ahead for power supply and for reducing drift. The speed was 5–6 knots.

Directly after the watch was changed, the officer went down to the engine room for draining, which took him about half an hour. He had to go down to the engine room from time to time to drain from leaking water.

The computer, used for the navigation, was restarted at 12:43 hrs according to the log book. This had to be done from time to time, according to the officer, due to the computer sometimes turned off. The intention of the officer was to pass close to land, but to have the chart's west cardinal marks on the vessel's port side. This included passing Västerflaket on the western side. His intention was thus not to navigate the vessel through the same fairway as the heavy traffic.

After some time, a west mark, Viragogrund, showed up on the starboard side (see Figure 2 and 4), which the helmsman pointed out to the officer as being incorrect. The officer immediately instructed a more westerly course, according to his statements, but remarked that a depth of five metres was enough for them to pass. The officer has claimed that he at this time also was busy in the engine room draining.

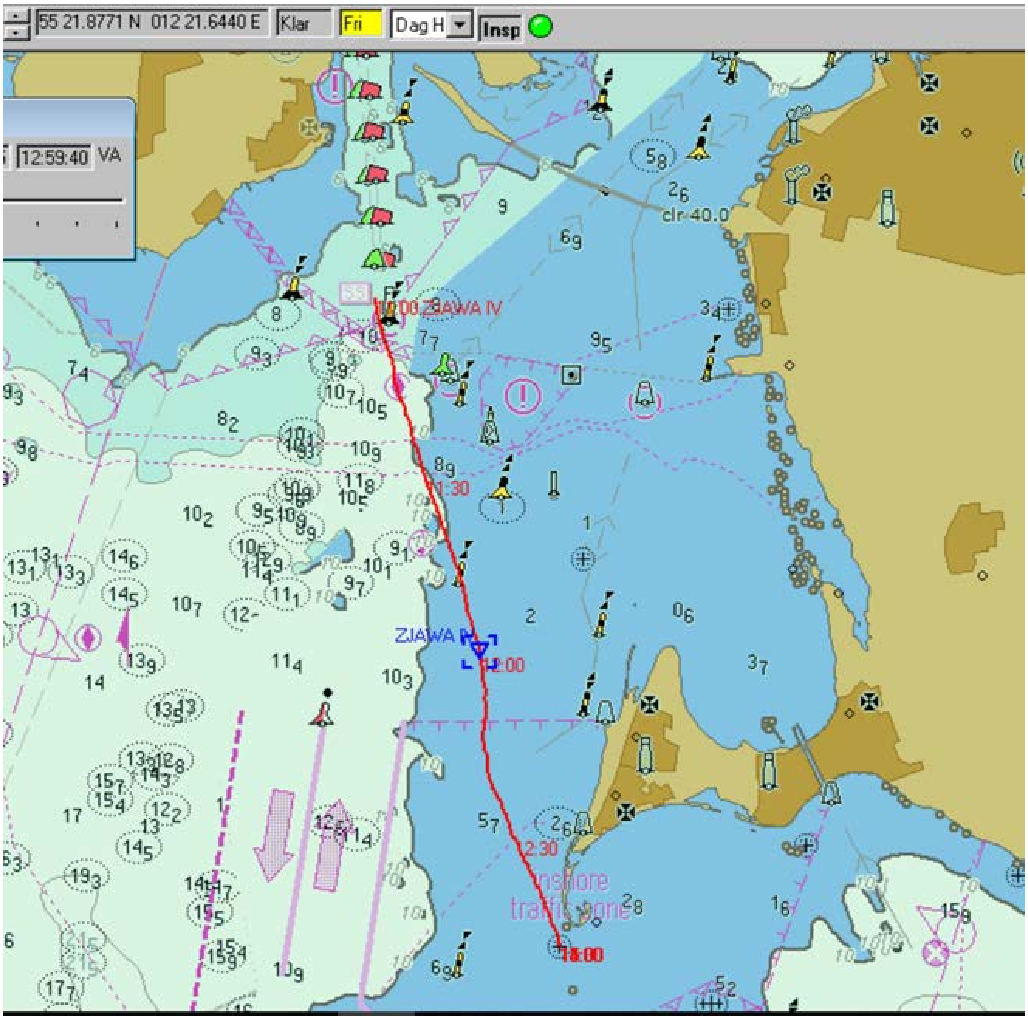


Figure 2. AIS image. ZJAWA IV's track is marked red. The track is close to the eastern side of a west mark (see centre of picture or Figure 4). The lighthouse Falsterborev is down to the left, outside the picture, while the area Falsterborev is where the AIS track ends. © Sjöfartsverket nr: 10–01518.

At 13:48 hrs ZJAWA IV touched ground in position N 55° 21.1′ E012° 48.2′ and thereafter grounded a couple of hundred metres further south. Wind and sea later moved the foundered vessel yet a bit more east (see AIS[1] track in Figure 2).

In the log from the Swedish JRCC[2] it is noted that a PAN-PAN[3] was received from ZJAWA IV at 14:10 hrs, asking for assistance since the

1 AIS (Automatic Identification System) makes it possible for a vessel to see information about other vessels on its own radar screen. The information is available at the Swedish Maritime Administration and reconstruction of a voyage is possible.
2 Joint Rescue Coordination Centre.
3 PAN-PAN is an urgent radio message.

vessel was aground and banging against rocks, though not taking in water or leaking oil, according to the log.

1.2 Damage to ship

The vessel was salved and brought to the port of Dragör, Denmark. The exterior damage to the vessel was restricted to the port side. Railing and planking was damaged along the vessel's full length. There were scratches and chafe damage along the side from 5 to 13 metres of the hull length (seen from the bow). The bow protection was damaged and torn.

Below is a more detailed list of damage (the figures give the distance from the bow):

- 3–6 m, at the keel: planking torn and with holes (up to 50–60 cm).
- 6–7 m, close below water line: hole into the galley approximately 60 cm diameter.
- 8 m: planking torn away length 10 cm.
- 12 m: hole 60 x 50 cm.
- 14 m: hole 1 x 1 m (engine room).
- 14–16 m, at keel: planking pulled out and planking missing.

Figure 3. Some of the damage on ZJAWA IV.

Damage inside the vessel is not described in detail, but incoming sea water had damaged engines and electrical equipment.

1.3 Site of occurrence

To reach the water area west of Falsterbonäset in the southern part of the Sound from the north, there are two fairways of importance, Drogden and Flintrännan.

Drogden sets generally speaking straight south and is a little bit more than 10 M[4]. On this side of the Sound, the western side, the traffic passes above the Sound road link (built 1995–2000), which passes in a tunnel beneath the sea bottom. Drogden is marked with light buoys, placed two-by-two.

Flintrännan is the eastern fairway. It is somewhat shorter, just under 8 M long, and sets in a south-westerly direction. This fairway passes under the Sound Bridge and is well marked with a number of small lighthouses along the sides.

For the smaller tonnage, there is yet another fairway close to the Swedish mainland, Trindelrännan, which connects to Flintrännan in the northern end, close to the lighthouse Flintrännan NE. This fairway sets first to west-south-west and then turns to the south to continue straight south towards the lighthouse Höllviken. Trindelrännan is not as well marked as the two other, larger fairways.

From the lighthouse Höllviken there are three other fairways to choose from: the fairway towards Falsterbokanalen, heading straight east-south-east, cutting through the narrow part of the isthmus, making it easy to reach open water on the opposite side; Kogrundsrännan, passing south through a shoal towards the port of Skanör, from where you may turn westward to reach open sea; and finally Lillgrundsrännan, heading west-south-west, ending in the same area as the two bigger fairways Drogden and Flintrännan.

Lillgrundsrännan ends with the north cardinal mark Bredgrund, and about 2 M further south, the shoal is delimited in the south and east from the larger fairways by the west cardinal mark Viragogrund.

In the area where the fairways Drogden and Flintrännan end and converge, the lighthouses Drogden and Flintrännan respectively form distinct markers. About 5 M further south a Traffic Separation Scheme (TSS) begins, which yet another 6 M south constitutes a traffic circle around the lighthouse Falsterborev. From there, the TSS continues either to the south or east-south-east.

4 M is nautical mile (approximately 1 852 m).

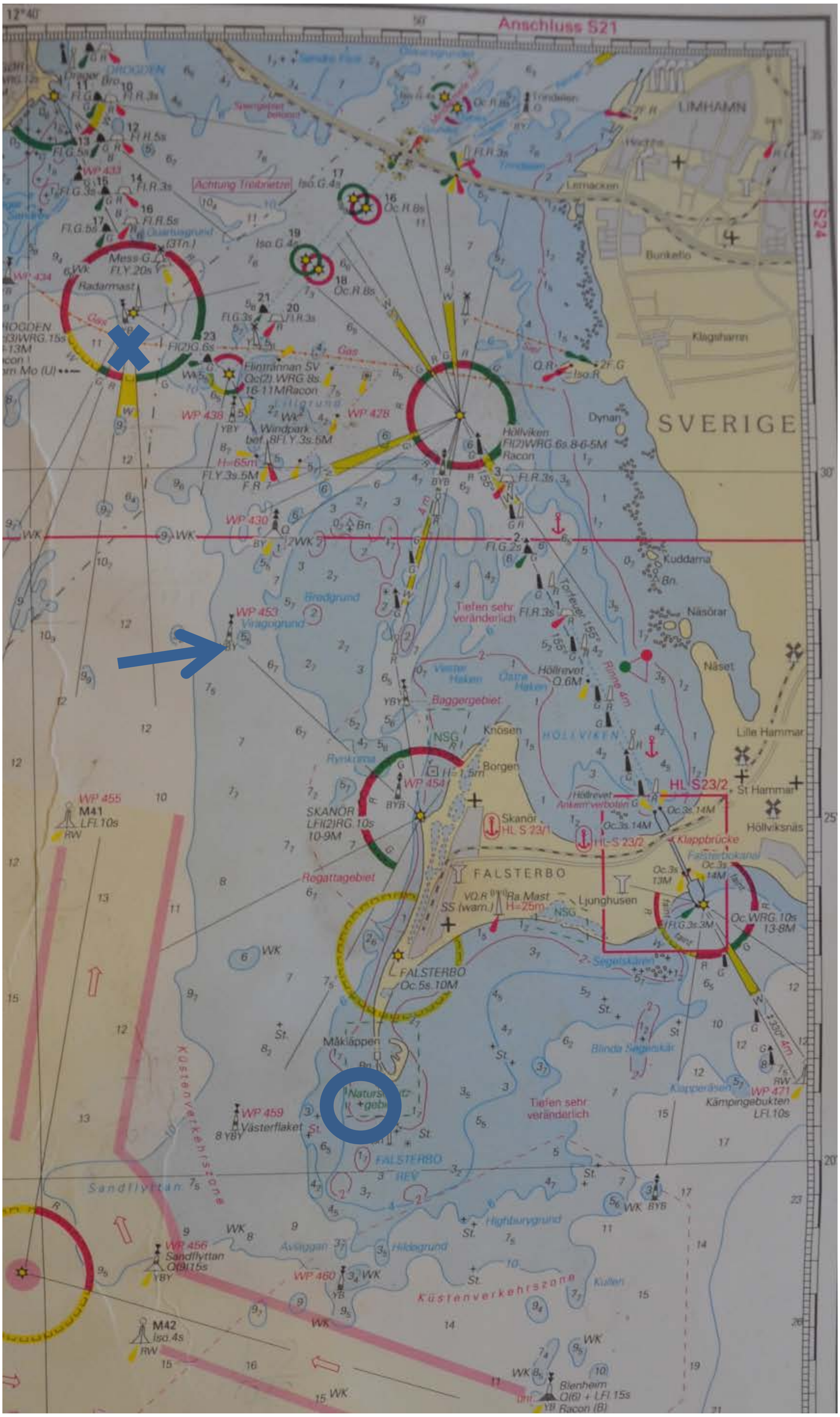


Figure 4. Chart showing the area concerned. The blue cross marks the area where the change of watch was taking place, the blue arrow points at the cardinal mark Viragogrund and the blue circle marks the area of grounding.

Between the TSS and Falsterboudde, where the lighthouse Falsterbo is situated, the water area constitutes an Inshore Traffic Zone (ITZ) and the further east you reach, the more and more shallow the water gets, turning into the shoals Västerflaket and Falsterborev. There are not many navigation marks in this area, but there is a west cardinal mark between the lighthouses Falsterborev and Falsterbo and a south cardinal mark close west of the shoal Hildagrund, which is the south spur of the shoal Falsterborev. Furthermore, there are a couple of beacons closer to land, of which the northern most is called Måkläppen. The cape consists of low land and has a blurry contour.

At the position for the grounding, which is well inside the 3-metre marking in the chart, there is a rock awash well marked in some large-scale charts (like coastal charts). This rock is however not marked in smaller scale charts (like archipelago charts).

1.4 Ship particulars

1.4.1 General

ZJAWA IV had been in Peterhead for a couple of weeks preparing for the remaining voyage to Poland. The engine had been exchanged but there were still some technical problems that needed attention, e.g. generators and heating system. This included the fact that the heating and the stove were not in working order. Instead a paraffin heater was obtained and placed in the mess room. However, the heater capacity could not fully replace the ordinary heating system. As the stove was not in working order, the crew had to accept food that was easily cooked with hot water. Furthermore the vessel leaked. Some 1–2 tons of water had to be drained every 6–8 hours. According to the owner, these circumstances were well known to the crew before the voyage.

1.4.2 Relevant description of equipment, navigational data and systems

On ZJAWA IV there was one radar, one AIS, two GPS units[5], one of which belonged to the vessel and merely gave a position whilst the other was in the master’s computer (see below) and, as stated, also gave course. Furthermore there was an echo sounder, which however was not readable. There was no automatic steering.

For navigation there were two computers. One belonged to the vessel and the other was the master’s private one. The latter contained, according to the master, updated charts for the voyage. Neither of the computers fulfilled ECDIS[6] standards.

Furthermore there were a number of paper charts in different scales, including sets for the voyage between Peterhead and Poland, printed

5 GPS (Global Positioning System) is a satellite positioning system.
6 ECDIS (Electronic Chart Display and Information System) is an electronic chart system of special standards.

in 2014–2015 and in smaller format (comparable to small craft charts). There was also a large British paper chart for the south part of the Sound from 1990, which did not however cover the Swedish side, Falsterbonäs and the area around the lighthouse Falsterborev.

To navigate, the master's computer was generally used whilst the large paper chart was kept on the desk, used for plotting. The smaller paper charts were not used during the voyage and were stowed away. The master has in interviews stated that he would not have accepted the assignment unless he brought charts on his own computer when he arrived.

On board there were also two magnetic compasses: one steering compass supposed to be at the wheel (make Autonautic) and a bearing compass (make Weilbach) that should have been on top of the roof of the navigation house (see section 1.11.1).[7] Neither of these compasses had a deviation table, and both of them were categorised by the crew as being "out of order".

During the voyage to Peterhead the crew had experienced problems with the steering compass, which reacted very slowly. The steering compass had hence a few months before the grounding been removed and been replaced by the bearing compass, which consequently had been moved from its ordinary place on the navigation house roof (see Figure 5). However, this compass did not work well in its new place, and they therefore kept the course by looking at the electronic chart in the navigation house, situated forward of and one deck below the conning place. The voyage was normally planned step by step as the voyage continued. This was done by the master some 24 hours in advance. After the passage of Drogden, the passage towards Bornholm was planned.

In the vessel's log a position has been noted every full hour. These show that the vessel has been brought with the true course 163–165°, which is well in line with the vessel's AIS track. The track also shows that the vessel has been brought close east of Viragogrund and passed a few cables[8] west of the beacon Måkläppen.

7 There is also information about a third compass, being kept in a store. This has however not been found and its existence has consequently not been confirmed.
8 Cable is a tenth of a nautical mile, i.e. approximately 185 m.

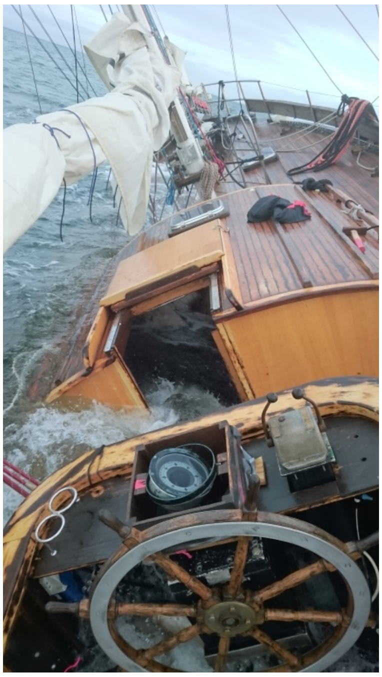


Figure 5. On the picture at the left, taken after the grounding, the bearing compass is seen in the place of the steering compass. The door in the middle of the picture leads to the chart room. Image: Maritime Education Centre of Polish Scouting and Guiding Association.

1.4.3 Crew

The master was 64 years old at the time and was an experienced yachtsman. He had crossed the Atlantic a number of times and sailed in the Mediterranean Sea. He has declared that he knows the waters in question pretty well. He had worked on ZJAWA IV on two occasions, one of which was an Atlantic crossing. He did not take part in the crossing in question, but came on board in Peterhead.

The navigation officer was 31 years at the time and had been engaged in yacht sailing for more than ten years and taken part in regattas and races. In September 2016 he quit his ordinary work, which he had had for five years, to again devote his full time to sailing. He had been on board ZJAWA IV for the first time in February 2016, when he came on board in Havana. This time he joined the vessel during her stay in Peterhead, and had thus been on board for four weeks. Altogether he had spent some three months on the vessel. This was however his first time in the waters concerned.

The helmsman was 67 years old at the time and was an experienced sailor. He held a master's ticket for ZJAWA IV and this time came on board in Peterhead.

1.5 Meteorological information

According to information from SMHI[9] there was a deep low pressure close east of Finland, moving southeast. A powerful high pressure covered the eastern parts of Central Europe with a ridge reaching over the North Sea. Over the southern Baltic westerly winds, deteriorating during the evening, dominated.

9 SMHI – The Swedish Meteorological and Hydrological Institute.

The visibility is stated to have been very good in the area concerned. Otherwise the following conditions were found:

Time	Wind direction	Speed at 10m level	Gusts	Temp air	Temp sea	Wave height sign.[10]	Current/direction
13:00	W	9.9 m/s	12.4	5.8	4	0.9	0.3 knots/eastw.
14:00	W	10.0	13.2	6.1	4	0.9	0.3 knots/eastw.
15:00	W	9.8	12.8	6.3	4	0.9	0.3 knots/eastw.

Figure 6. Table of meteorological circumstances.

According to people at the site, the waves were estimated to 1–2 m.

1.6 Emergency response

According to Chapter 1, Section 2, first paragraph of the Civil Protection Act (2003:778), LSO, the term “rescue services” denotes the rescue operations for which central government or municipalities shall be responsible for in the event of accidents or imminent danger of accidents, in order to prevent and limit injury to persons and damage to property and the environment.

As the VHF[11] call came to JRCC, Rescue ELSA JOHANSSON from the Swedish Sea Rescue Society’s station in Trelleborg was alerted and set course to the site. Already at an early stage it was noted that the area was most likely too shallow to allow ELSA JOHANSSON to approach the casualty vessel. As the Trelleborg station’s small boat was out of service, a small unit was engaged from the station in Lomma. This unit, Rescue FAMOUS, could reach the casualty vessel without any problems.

To start with, part of the crew was evacuated, and towing the vessel from the grounding position was discussed. However, the situation pretty soon deteriorated as the vessel started to take in water and list (see Figure 7). As a consequence, a decision was made to evacuate the crew in full. This was initially done by FAMOUS, but as one of the Coast Guard’s small units had reached the area, it evacuated some of the crew members.

When the evacuation was completed, the marine rescue operation ended. Thereafter, a larger unit from the Coast Guard was in place to watch the area in case oil should leak.

The rescue operation was performed without any major problems, though some equipment was damaged or destroyed by sea water, inter alia, a computer (which is said to be the master’s computer, i.e. the one that was used for the navigation).

10 Significant wave height is the average of the wave height of the top third of the waves during a 30- minute period. Single waves may be considerably higher.
11 VHF (Very High Frequency) is a specific frequency band for radio traffic.

Figure 7. The rescue operation. Image: The Swedish Coast Guard.

1.7 Inspections and regulations

1.7.1 The Polish inspection entities

The documentation from the Polish flag state authority, issued after an inspection in Lisbon in June 2016, has notations regarding magnetic compasses as follows: one Silva Autonautic[12] and one Weilbach. Of these, the latter is registered as a reserve and bearing compass. No other notes about, e.g. deviation tables, exist. According to information from the flag state authority, a vessel of the size of ZJAWA IV does not need to have deviation tables for her compasses.

During an inspection, the compasses are inspected visually and it is ensured that required documentation is in place. The placement of the compass and any potential interference from electrical equipment or other instrumentation are not controlled, but if in doubt contact may be made with the classification society for clarification. The technical standard of a vessel, including placement of compasses, is approved by a classification society.

1.7.2 Relevant legislation and demands

According to Chapter 2, Section 1 of the Swedish act on vessels' safety, a vessel is seaworthy only if it is so constructed, built, equipped and kept in order that it, taking its purpose and area where it is, or is supposed to be, operating in into consideration, safe enough to

12 As a matter of fact, Silva and Autonautic are two different makes.

give satisfactory protection against marine casualties. This regulation is applicable also for foreign vessels in Swedish territorial waters.

Applicable international requirements concerning navigational equipment for this occurrence are found in SOLAS Chapter V, Regulation 19. They stipulate, inter alia, that an adjusted standard magnetic compass, or other means, shall be brought and display reading at the main steering position, that means of correcting heading and bearings to true shall be in place, and that charts and nautical publications for the voyage shall be on board (see appendix).

Concerning voyage planning, the international demands require that the master before departure shall ensure that voyage is planned with appropriate charts and nautical publications and that IMO guidelines and recommendations are taken into account. The guidelines referred to are mainly Resolution A.893(21) *IMO Guidelines for Voyage Planning*. Following the guidelines, a vessel's route shall be charted with courses, dangerous areas and reporting points (SOLAS Chapter V, Regulation 34).

1.8 Organisational and management information

ZJAWA IV is owned and operated by a sea scouts association and used commercially for charters. In recent years, the vessel has been used in the Mediterranean Sea and the West Indies, hence crossing the Atlantic a number of times. The manning, including this voyage, has been based upon voluntary work.

In the organisation there is a person ashore with a designated responsebility, DPA.

1.9 Route planning

The master has declared that he showed a planned route to the ongoing watch team, which he regards to be reliable and experienced. There was no discussion about the routing. After the grounding he discovered the changed plans. According to him, it is not normal to change the planning as was done in this matter, and he has not experienced this before.

According to the officer, however, such a detailed planned route did not exist. Instead, the master instructed him in general terms to keep within the limits to navigable waters, keeping a safe distance to other vessels. Thus, he does not consider himself deviating from the master's instructions. A two-mast vessel like ZJAWA IV is heavy to work with, and it may take a couple of hours to set or haul sails, which is done manually. Hence, there are reasons to plan the navigation to reduce the need to change sails, thus reducing the work requirement. According to the officer this was the reason why he brought the vessel east of other traffic. By this it was no need to take other vessels into consideration and unnecessary changes of course or sail set were avoided.

From the interview with the officer, it has also been found that he, after passage of Viragogrund, spent much time under deck draining. It was also apparent that he could not tell the difference between the lighthouse Falsterborev, the lighthouse Falsterbo and the shoal Falsterbo and that this was his first time sailing in these waters.

1.10 Work environment factors on board

From the interviews it is evident that it was cold and damp on board due to the absence of a functional heating system and hence difficult to sleep. The time off duty was spent in a damp and cold bunk. Furthermore, the awkward food situation contributed to the social relations not being very good. There are witness statements about a poor and irritated atmosphere on board.

1.11 The compasses

In order to examine the technical circumstances for compasses at the wheel, SHK has had an expert investigation carried out (see appendix) of the compass of the make Autonautic (see Figure 8), originally mounted at the steering wheel, but later put away by the crew and replaced with the larger compass of the make Weilbach. The investigation showed that the Autonautic compass, under the circumstances valid at the steering wheel, demanded more or less total stillness and friction-free conditions to find north. As little as 10 per cent of the power to find direction was still left during the test when it was in the worst scenario. The needle had thus turned extremely slowly, if at all.

Figure 8. To the left is the bearing compass (make Weilbach, see also. Figure 5) and to the right the steering compass (make Autonautic).

When the Autonautic compass was tested with no magnetic distortion it has moved normally with the internal error within the interval -1° to +1°.

To place another compass, not adjusted, in a place requiring such a compensation would need a deviation table with values between -50° and +50°.

Both compasses' original placing at the wheel and on the roof respectively have been confirmed by photographs made available to SHK.

1.12 Former casualty

In June 2016 a leakage occurred on ZJAWA IV as she was on voyage in the Baltic, and evacuation of 12 of the 15 people on board was conducted (SHK file no. S-93/16). The cause of the leakage is said to have been faulty caulking of the hull. The occurrence was investigated by the Polish State Marine Accident Investigation Commission, but the report is not translated from Polish to any other language.

2. ANALYSIS

2.1 Outlines and limitations

The incident has occasioned an analysis of the navigation performed on the vessel before the grounding. SHK has, however, not found any need for dealing with navigation legislation in any depth. However, the circumstances prior to the grounding, and the extent to which these may have had any influence on the course of events, have been examined.

The vessel's technical shortcomings have been addressed to a certain extent, but SHK has refrained from making a deeper analysis of whether the vessel was seaworthy or not for this voyage. SHK has also not found any reason to more closely investigate and address the rescue operation.

Even though the poor performance of the vessel's magnetic compasses cannot directly be linked to the grounding, SHK still has found it being of interest, as an observation, to discuss this subject as compasses constitute important navigation aids on vessels with the same equipment standards as ZJAWA IV.

2.2 Circumstances prior to the grounding

The prerequisites for the voyage were not the best. The vessel had a new main engine, but the heating system and the stove were not operational which resulted in the vessel, except from the mess room, being cold and damp. The hull was leaking and had to be drained regularly. These technical problems, one of which was a leakage that has to be considered major, make it questionable if the vessel was seaworthy and in adequate condition for a voyage across the North Sea. It may in this context be mentioned that the vessel had earlier been involved in an incident due to hull leakage, resulting in most of the crew being evacuated.

Discussions between the owner's representative and the original crew caused parts of the crew not to complete the voyage as they considered it not to be safe enough. The voyage from Peterhead had to be carried out with crew replacements.

The weather was harsh and made it necessary to make unplanned stops. There are also statements claiming that there was a bad atmosphere onboard. Further, the diet was poor and limited to what could be cooked with hot water only.

The social prerequisites, combined with the lacking heating system and poor diet, has probably affected the level of performance of the crew. Even if the crew was prepared for these conditions, it is the assessment of SHK that the circumstances were not good enough to bring the vessel safely and controlled through her voyage.

In principle, the responsibility for the technical standard and the planning of a voyage rests on the master, but in an activity based upon voluntary contribution, it cannot be ignored that this responsibility also rests on the owner or its representative to a significant degree. At the very least, the owner should ensure conditions good enough for the master to be able to take a master's responsibility (see section 2.3).

2.3 Rout planning and Navigation

The instrument mainly used for navigation was the master's private computer and the electronic chart therein. Aside from the computer being in such a state that it needed to be restarted now and then, it did not fulfil the requirements to be used as the main navigational method. As a support for navigation a British paper chart from 1990 was used. This chart was published before the Sound Bridge was built and the wind parks in the southern part of the Sound were raised. The area where the grounding took place was not in the paper chart.

The new paper charts, being brought on board for this voyage and fulfilling the requirements, were still stowed away. Complementary navigational methods, like radar positioning, were not used. The helmsman did not have access to a functional compass. That safety barrier, which a functional compass constitutes, had thus been eliminated. The demands on using other, complementary methods to fulfil the navigation, may therefore be deemed to have increased. As there was no functioning compass, information from the GPS:s, situated in the chart room, was used as course values.

The officer was told by the helmsman that the vessel was passing on the eastern side of the west mark Viragogrund, instead of the western side according to the officer's plan. Despite this, enough action was not taken by the officer. Instead he declared that 5 metres' depth was enough to go clear. This suggests that he was aware of the vessel being outside the 6-metre contour line. In the log book, there is also a position for 13:00 hrs corresponding to the AIS track. Altogether this gives reason to assume that he knew where the vessel was at this moment.

There is nothing to prevent a vessel from passing east of a west cardinal mark, if the circumstances so permit, but it should raise concerns about the vessel's navigation and its position, especially if the vessel is navigated in waters outside of daily routines. Hence, it is difficult to understand how the voyage could continue until the beacon Måkläppen was passed that close, and the grounding occurred, without the officer taking any action. A possible explanation could be that the position in the log book was not compared to the corresponding position in the chart, or that the electronic chart which was in use was deficient, e.g. due to incorrect settings. The low and flat land, which could give an impression of being further away than it really was, could also be a contributing factor. A significant eastward drift, due to wind and current, should also not be ignored.

To be noted is that a rock awash, marked as such on a large-scale chart, is not seen on a chart of smaller scale. The fact that charts covering the same area may be different depending on the scale used, emphasises the importance of not relying on only one navigational method. This is especially important when electronic charts are used, as it is very easy to change scales.

From the interview with the officer it also appeared that he was not sure about the difference between the area Falsterborev and the lighthouse Falsterborev. This may have made him believe that he was in general following the master's instructions as he rounded the area Falsterborev instead of the lighthouse Falsterborev, the latter being considerably more to the west. This confusion would further mean that the relief, when the master handed over the watch to the officer, was insufficient. It should also be noted that the officer during the watch was conducting other duties in the engine room (draining) and was consequently not giving his full attention to the navigation.

Altogether this demonstrates deficiencies in both the planning and the performing of the voyage (see also section 2.2 and 2.4). The fact that the master claims that he would not have accepted the assignment if he had not brought his own computer further suggests that he did not expect, or at least could not take for granted, that the voyage was well planned. SHK is therefore of the opinion that the owner should enhance the control over how the duties are performed on board its vessels to ensure safe performance.

2.4 Additional observations

2.4.1 The magnetic compasses

The magnetic compass of the make Autonautic was on ZJAWA IV placed at the steering wheel, which has to be regarded as unsuitable as it was too close to interfering sources, such as the engine handle. To have correct readings in such a place, a powerful correction is necessary, which in turn weakens the ability of the compass to find north and makes the needle move slowly.

That this was the case regarding the Autonautic compass is confirmed from photographs taken prior to the grounding, as well as measurements made on behalf of SHK after the occurrence. It also explains why the crew felt that the compass was out of order. The ability to find north was so weak that the needle seemed to be still.

The crew tried to resolve the problem by changing the Autonautic compass to a Weilbach compass, which was thus moved from a relatively undisturbed placement to a position with totally different magnetic fields, causing interference. This made the crew believe that this compass was also out of order.

How the compasses were handled shows that the crew lacked sufficient understanding of how compasses work and should be treated. This conclusion is also supported by the absence of deviation tables, and that these were not asked for, either by crew members or the Polish inspection bodies. This is not in line with international requirements.

The procedures for approval and controlling compass placing and function have thus not been functioning properly. Apart from the shipping company, this also concerns the flag state and the classification society.

3. CONCLUSIONS

3.1 Findings

a) Neither the heating nor the stove was in operational order on board.
b) The diet was poor and limited to such food that could be prepared with only hot water.
c) Available, updated paper charts were not used, but the navigation was instead executed on old paper charts and the master's private computer, which did not fulfil ECDIS standards.
d) The placing of the compasses and the knowledge of their function were inadequate.
e) This was the officer's first voyage in the area concerned.
f) The officer paid some attention to other duties than navigation (draining).
g) It cannot be ruled out that the officer confused the area Falsterborev with the lighthouse Falsterborev.
h) The officer deviated from the route planned by the master.
i) The vessel was exposed to eastward drift.
j) The vessel entered shallow waters and grounded.
k) The voyage was insufficiently planned and inadequately performed.
l) The poor circumstances on board have most likely affected the planning and performance of the voyage negatively.

3.2 Causes

The grounding was caused by the vessel being navigated on a route that was supposed to be safe, without the position being controlled with an alternative navigational method. Drift, caused by wind and current, may have brought the vessel closer to the shallow area than expected. A contributing factor was most likely that the officer partly paid attention to other duties below deck. Further, it cannot be ruled out that the area Falsterborev and the lighthouse Falsterborev may have been confused with each other, contributing to the vessel being brought into the shallow area.

Poor preconditions with poor diet and damp and cold conditions onboard have most likely affected the planning and performance of the voyage negatively.

4. ACTION TAKEN

The company function of Maritime Education Centre of Polish Scouting and Guiding Association has, according to statements, due to this occurrence introduced a Safety Management System (SMS) to ensure that safe navigation and good seamanship is performed by its crews.

5. SAFETY RECOMMENDATIONS

As the company has taken relevant and adequate action, SHK refrains from issuing any recommendation (see section 4).

The Polish Flag State Authority is recommended to:

- Complement its inspection procedures to make them better embracing control of function and use of magnetic compasses (see section 2.4). (*RS 2017:06 R1)*

The Swedish Accident Investigation Authority respectfully requests to receive, **by 5 March 2018 at the latest,** information regarding measures taken in response to the recommendation included in this report.
On behalf of the Swedish Accident Investigation Authority,

Helene Arango Magnusson Jörgen Zachau

Appendix – Examination of compass

This document is a translation made by SHK of the original report of the technical examination. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

REPORT

Date: 28/08/2017

Report No.: 2017-1

References

Swedish Accident Investigation Authority

Box 6014
102 31 Stockholm

Assignment:
Susanna Gustafsson
sg.golfcon@tele2.se

Contact person instruments and measurement technology dpt.:
Erik Sandberg
compass@tele2.se
070-690 96 54

Reference:
Consultancy agreement 18/04/2017
File no.: S-203/16

Examination of compass

On behalf of the Swedish Accident Investigation Authority, SG GolfCon has provided a technical examination of the status and function of a compass belonging to the vessel ZJAWA IV after its grounding at Falsterbo Reef on 5 December 2016.

The examination has been carried out at the company's compass workshop and control station with the calculation support of expertise at the Swedish Compass Adjusters Association (SKJF). Furthermore, Linnaeus University, Kalmar Maritime Academy, has contributed advice, analytical work and review of the investigation findings. The report has been compiled by Erik Sandberg.

SG GolfCon

Susanna Gustafsson
Owner
Degree of Licentiate, meteorologist

SG GolfCon

Erik Sandberg
Degree of Bachelor, captain, measurement engineer
Authorised compass adjuster

Address: SG GolfCon
Södergatan 62
274 34 Skurup
Tel: +46 (0) 411-459 87 / +46 (0) 70-360 56 88
E-mail: sg.golfcon@tele2.se

Control station and workshop
+46 (0) 70-690 96 54
compass@tele2.se

Org Nr/VAT NO: SE 630 120 234 401

Assignment

Background and questions

The Swedish Accident Investigation Authority (SHK) has established that the vessel has had two compass locations, where one magnetic compass has been placed at the steering position and a second in the proximity of the pilothouse. The latter has been intended for taking bearings.

The crew has stated to SHK that the original steering compass had functioned very poorly and that during the voyage towards more northern latitudes the magnetic compass at the steering position had therefore been exchanged.

On behalf of SHK, SG GolfCon has therefore investigated and analysed the following three particulars:

1. How do the conditions for the function of the compass at the steering position change if this is exchanged in the manner applicable in this case?

Specification: If the Weilbach compass is moved from its "ordinary" placement on the cabin roof to the steering position (with a placement between control levers and the Garmin equipment), how do the conditions for the function of the compass change (or how might they change)? No adjustment of the compass was made in connection with the move.

2. Establish that the correct magnetic compass is examined.

Specification: Can the original compass at the steering position on the images you have seen be the same as the one you have received for examination? In the vessel, the original compass at the steering position has been referenced as "Silva compass" while the one you have received for examination is of a different, Spanish make. In footnote: There are also details about a third compass, according to information kept in a storage room. This has, however, not been found, and the existence of this compass has thus not been possible to confirm.

3. Opinion on the examined magnetic compass regarding standard and function.

Specification: We would like an opinion on the standard and function of the compass you have received for examination. This opinion is to take into account the conditions of placement according to images. Note also that the compass was found in a locker in the casualty vessel

---

Overall results

Changed conditions when exchanging compass at the compass location

Several conditions have changed during the voyage and in conjunction with the exchange of compasses.

The most tangible one is that the compass location's means of adjustment have been removed (these were built into the original compass), which in this case has yielded a stronger horizontal directive force but with a greater deviation[1]. The exchange of compass has thus entailed the compass rose exhibiting a faster alignment, but this is towards an apparent magnetic north.

That the vessel has undertaken a voyage between different geomagnetic conditions means that the disturbances have varied, which means that a compass location might very well have functioned satisfactorily in a place located closer to the magnetic equator. Both the geomagnetic conditions and the effects induced by the magnetic field on surrounding iron can cause detrimental disturbance if the compass location does not follow the intended standard.

Also, compass locations on smaller vessels often become poorer or even unusable over time with reference to refurbishments and new equipment that is placed incorrectly. This is today more the rule than the exception on smaller vessel types, even in new production. At a disturbed compass location, only compensating the compass location with the simple correctors that can be found built into some pleasure boats and B lifeboat compasses means that the compensation will only be reliable in a limited area where the magnetic field's components are relatively consistent.

The foundation required for a functioning compass, that is, an acceptable compass location for the intended voyage, is lacking for the position of the steering compass. This foundation is shown by ISO 25862:2009 *Ship and marine technology – Marine Compasses, binnacles and azimuth reading devices.*

The measurements which were subsequently possible using the compass that was fitted with built-in correctors – the one that was first mounted at the steering position – show that attempts were made to compensate for disturbances that even exceeded the deviation value for permanent horizontal magnetism which the correctors are supposed to be designed for in order to receive type approval[2] .

A magnetic compass that is mounted at the same location, but without correctors, will exhibit the compass location's deviations corresponding to those for which attempts were made to compensate for.[3]

---

[1] Deviation: the deviation that the magnetic compass indicates with respect to the direction of magnetic north.
[2] ISO 25862:2009, 5.2.2.2 - (720/H)º
[3] Non-applicable exceptions are presented in the chapter in question.

The examined compass

SG GolfCon has been able to establish that the correct compass has been examined.

The compass that has been examined is of the model Autonautic C15. It is the same individual as is seen on the images from the vessel that have been sent to us.

Opinion on standard and function

Despite some deficiencies found, it has been established that it is possible for the examined compass to function sufficiently if it has been placed at a compass location that fulfils the requirements of ISO 25862:2009 Annex E and if it has been correctly adjusted according to Annex G of the same standard. However, the simple design of the compass will mean that the compass rose will exhibit a noticeable tilt when the compass is in a different geomagnetic area than that which it is designed for.

Method

The control station

The controls have been performed in a controlled magnetic environment that has been adapted to the test conditions described in ISO 25862:2009.

The temperature of the compass has been controlled with an IR thermometer.

The magnetic field is controlled with duplicate magnetometer equipment.

Magnetometers have also been used to measure the strength of the compass magnets.

A revolving compass test platform has been used for measuring settling times, lag, internal friction, tolerances and readability, and establishing if iron is present in the compass design. Visual inspections are also facilitated by means of the instrument's optics.

Setting and reference to magnetic north have been controlled with the workshop's two reference compasses of types air and fluid, and that the workshop's "control north" has been compared against the calculated change in the magnetic field models[4].

Anomalies in the magnetic field have been continuously controlled during the measurements and subsequently by means of historical data from the nearby observatory.

The compass has initially undergone the test points required for a renewed individual certificate[5], with the exception of cooling and heating tests[6]. In order to assure the quality of

[4] IGRF/BGS/WMM – geomagnetic models
[5] In Sweden termed test certificate (intyg om översyn).
[6] The reason was that cooling and heating tests could worsen the detected damage to the dome glass (actually plastic) before the photo documentation of the parts had been carried out. This test element also lacks relevance for the investigation.

calculations and test results, extended tests have been performed to control manufacturing tolerances. These minor errors have been entered into the analysis at a second stage by means of a correction of readings.

A supplementary test method in addition to the standard has then been produced in order to control the built-in correctors' effect on the compass for the position they had been in. In this way, we have been able to measure the magnitude of deviation of fore-and-aft magnetism and of athwartship magnetism for which attempts had previously been made to compensate for. After analysis of the method's limitations, we can therefore with good probability give an answer as to the magnitude of the effects after the exchange of compass.

We have established that the correctors have not changed position to any great extent for a long time. This is apparent upon closer inspection of the contact surface between the correctors' axes where there is no fouling. It is therefore reasonable to assume that the correctors have been in the measured position for the last few months. The crossed axes are shown in Appendix 5.

Finally, the magnetic compass has been dismantled in order to document any deficiencies or damage that might affect the results. Results beyond the assignment have been presented separately.

SG GolfCon has not examined the vessel's compass location on board, and parts of the opinion are based on the image data that SHK has provided.

Expert group

For development of the supplementary test method, including program and database customisation, the Swedish Compass Adjusters Association (SKJF) has contributed support through Lieutenant Commander Nils Möllerström, authorised compass adjuster and former head of the Swedish Navy's control station in Karlskrona.

Advice, analytical work and review of draft and report have been undertaken by Linnaeus University, Kalmar Maritime Academy, through subject expert Captain Jan Snöberg, senior lecturer.

The establishment of the expert group has been communicated to the investigator in charge within the scope of the assignment and the group's participants have been informed of the confidentiality of the investigation.

1. Exchange of compass at the compass location

Conclusion

The Weilbach compass has with certainty exhibited great deviation on a par with what has been measured in the examination. The compass has probably been perceived as faster in its alignment due to the fact that the correctors – that is, the permanent magnets which are built into the compass that was exchanged – have been removed from the compass location. It can be considered confirmed that the removed correctors were by far the greatest factor in changing the conditions for the functioning of the compass following the exchange.

Fundamentals

A vessel's compass location shall have as little effect from the vessel's magnetism[7] as possible. For this reason, standards[8] have been produced to ensure that the magnetic compass is able to function in what remains of the Earth's magnetic field at the compass location. For the sake of simplicity, the material part, namely the horizontal field [H] on board, is termed "directive force" in the discussion below.

Appendices 1 and 2 contain explanatory images of the components and magnetic fields mentioned.

It is generally said that a magnetic compass functions up to the latitudes 80º north (N) and south (S), respectively, which is a rough generalisation to describe the field strength of the magnetic field's components. The horizontal field strength that exists at the compass location on board is decisive to the compass rose's alignment ability and speed and the ability to overcome internal friction. A clearer generalisation, however, is that the horizontal directive force diminishes with the cosine function for the magnetic latitude; the directive force is at its strongest around the magnetic equator and has halved at a magnetic latitude of 60 degrees. The converse relationship holds for the vertical component [Z] in the total field [F].

This means that a permanently magnetic object, e.g. the buzzer in a chartplotter or the speaker/microphone in a VHF radio, which is placed alongside a compass yields various strengths of effect (deviation) depending where the vessel is. The object yields a somewhat smaller disturbance at the magnetic equator and a somewhat larger disturbance the more the vessel moves towards the poles. The safe distances to the magnetic compass that have been established for each piece of marine equipment, and which should be in user/installation instructions, are only applicable when the compass location is fundamentally acceptable.

Ferrous objects, which need not themselves be permanently magnetised, also form induced magnetic poles depending on the iron's form and placement, the vessel's heading, and on the magnitude of the magnetic field's vertical and horizontal components where the vessel is. By way of example, a fire extinguisher that is standing vertically can be completely without induced poles at the magnetic equator, while an increasingly strong blue pole is formed near its top during the vessel's movement northwards (and conversely, red pole formation south of the magnetic equator). If there are vertical objects with iron content near the compass, they

[7] Vessel magnetism is divided into permanent, induced (transient) and semi-permanent magnetism
[8] ISO 25862:2009

will attract one of the compass magnet's poles; the effect increases towards the poles. However, a horizontally lying iron object exhibits a diminishing induction during the vessel's movement polewards. If the horizontal iron is lying along the field lines, N-S, the effect is at its greatest. If the horizontal iron is lying across the field lines, the induced effect is at its lowest – practically non-existent.

In order for the magnetic compass to function satisfactorily and reliably on a vessel that sails between places where there are major differences in the magnetic field, the conditions are:

- that there are sufficient distances between compass and permanently magnetic objects/magnetic material
- that there are sufficient distances between compass and iron
- that the voyage has been preceded by relevant compensation
- that there is control over the residual deviation remaining after the compass location's compensation; that is, production of a deviation table/deviation curve where the residual deviation for this vessel shall not exceed +/- 4º upon local compensation, and upon a second compensation at the place of deviating magnetic latitude +/- 5º (requirement for “latitude-resilient” compensation). The table's accuracy shall in itself be better than 2º [9].

In order for the compass location to function as intended in places outside a limited area, such as the Baltic Sea/North Sea, it is necessary for:

- the deviation resulting from permanent magnetism to be compensated with permanent magnets
- the deviation resulting from induced magnetism to be compensated with iron

Even if a vessel is mainly built from non-magnetic material – e.g. GRP[10] or wooden structures – the magnetic poles that can be formed in controls, CO_2 canisters for life rafts, gas cylinders, etc. must be taken into account.

Rules and “Best Practice” for compass exchange

SOLAS Chapter V 2.2.1 states that vessels with a gross tonnage over 150 shall have a spare magnetic compass (directly) interchangeable with the ordinary one. If a vessel has soft iron correctors (D correctors and/or Flinders bars), a powerful compass magnet can induce (undesired) magnetism in these. For this reason, in order for the previous deviation table to be directly reliable, the compass magnets should be of equivalent strength. Independent of vessel size, this “Best Practice” is applicable when soft iron correctors are alongside the compass.

The compass exchange in question

The original compass, an Autonautic C15, has a compass magnet with a strength stated by the manufacturer to be 170 mAm^2, which it also reached during the control.

Iver C Weilbach's compasses of the type in question have a compass magnet with a strength of approximately 3 000 mAm^2 [11].

[9] ISO 25862:2009 Annex G
[10] Glass Reinforced Plastic
[11] Based on the compass workshop’s/control station’s previous measurements of the compass type.

Even though these compasses can, respectively, represent the weakest and almost the strongest compass magnets found in marine compasses, the large difference in strength has not had any decisive significance as soft iron correctors have not been mounted. However, minor disturbances might have arisen on account of differences between the compasses in induced magnetism in other iron in the direct proximity of the compass. This is unclear and cannot be investigated other than with physical controls on board.

Photo-interpreted compass location examination

Conclusion

Derived from the images that have been sent to us, it is established that several objects can affect the magnetic field at the compass location. See Figures 7, 8 and 9.

Observed objects with effect potential

<u>GPS navigator</u>

This is with great certainty placed within the safe distance for the magnetic compass. One deficiency is that the manuals we have found for Garmin's GPS120 series do not specify any such safe distance. For corresponding, but later manufactured models, 35 cm is specified as a minimum. In addition to this, and it is more than common, the instruments' attachment brackets might be manufactured from bent sheet metal. If there is a safe distance stated on the instrument, the attachment bracket is not usually included in this. Besides this, it is not uncommon for these attachment brackets to be designed, or adapted on board, so that the instrument can be turned. Large variations in the deviation can then occur depending on the temporary turn. Even without access to the manufacturer's data or access to the relevant navigator for measurement, we can establish that it had disturbed the compass location to some extent, as the distance shown by SHK's photo documentation is small.

<u>Holder for handset (assumed to belong to Marine VHF radio)</u>

If a speaker/microphone is mounted at this place, its permanent magnets will add deviation to the compass location and thereby with certainty a disturbance that can vary depending on whether or not the handset is placed in its recess.

<u>Controls and wheel</u>

These are normally manufactured in as non-magnetic a material as possible. It does however occur that steering gear and controls, in their various positions, have affected nearby magnetic compasses. Without measurement or control at the location, no opinion can be given, even if action of rust might suggest iron in the design.

<u>Electrical installations</u>

The alternating current fields have not affected the compass. If there are standard DIN rails in the electrical cabinet, these are normally in iron, which in this case could form a weak induced field through asymmetrical horizontal iron port of the compass.

Direct current fields have a detrimental effect depending on power output and cable position. This type of disturbance can vary.

<u>Other iron</u>

The fire extinguisher’s placement (port of the wheel) has, with increasing magnetic latitude, added deviation to the compass location with induced magnetic pole formation on its ends. In the northern hemisphere, this attracts the red pole (N) of the compass and contributes a deviation that depends on the vessel's heading.

A number of objects, which depending on material composition might be magnetic or induced by the Earth's magnetic field, are found under the compass location, among them a longer symmetrical athwartship iron (sheet rail forward of the steering position) and asymmetrically placed vertical irons on either side of the compass location (ventilation pipes).

Summary of photo interpretation

Compass locations on smaller vessels often become poorer or even unusable over time with reference to refurbishments and new equipment that is placed incorrectly. This is today more rule than exception on smaller vessel types. Only compensating the compass location with the simple correctors that are found built into some pleasure boats and B compasses means that the compensation will only be reliable in a limited area where the magnetic field's components are constant. The proximity to iron structures means that the disturbances can become greater than on a steel vessel where, if the standards for compass installation are followed, the steel in the entire vessel structure instead yields a general weakening[12] of the Earth's magnetic field without “free” induced magnetic “hotspots” detrimentally affecting the compass location.

As the compass location on this vessel is in all probability severely disturbed, all magnetic compasses that are placed at the compass location will have the same magnitude of error.

The errors, i.e. the deviation, will vary along the vessel’s latitude movement as permanent magnets are the only correctors that are available.

The photo interpretation shows that disturbances of various nature, some difficult to control, can arise at the compass site.

The interpretation is presented in more detail in the analysis section. Parts of the steering position's photo documentation that has been sent to us from SHK are shown in Figures 7, 8 and 9.

[12] The vessel's λ is a factor for general damping of the Earth's magnetic field on board. Normally 0.8 – 0.9 for steel vessels.

2. The compass in question is the same compass as is seen at the steering position on the images.

Conclusion

The compass is an Autonautic deck mount compass C15-0049 of Spanish make[13], Class B for rescue and lifeboats. It is established that this is the original compass pursuant to the question.

The compass that has been brought in for examination indicates identical heat damage to the sun protector as the steering compass in the image. The heat damage is internally very tangible on the part of the plastic glass which is under the sun protector. The sun protector has severe melting, which has also changed the character of the plastic on the outside of the protector. We have therefore with great certainty been able to establish that it is the same compass. The compass type otherwise appears to lack individual number marking. See Figure 1.

<u>Other names</u>

As the type approval of the compass under M.E.D.[14] is from 2015, it appears reasonable to assume that the vessel has previously had another magnetic compass at the compass location in question.

That a previous compass could have been a compass of the make Silva is not unreasonable, nor that this type of compass would receive this epithet with reference to its characteristics and design. Silva was a previously world-famous boat compass manufacturer.

Calling the compass a “Silva” may be attributed to and considered to be a purely formal error.

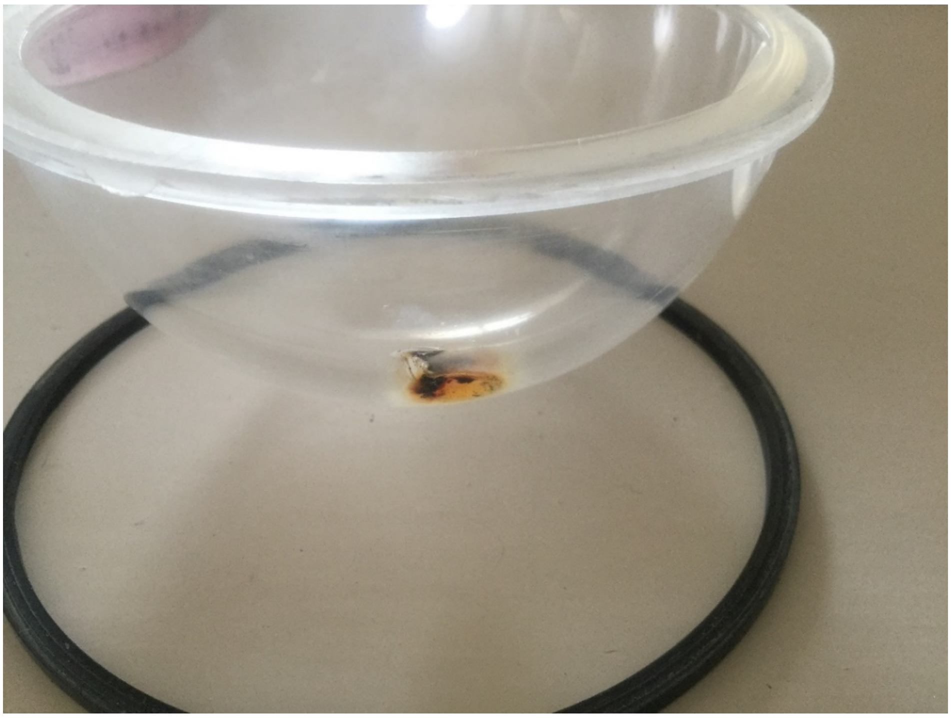


Figure 1. Dome glass with heat damage belonging to the examined compass. Photo: SG GolfCon

[13] See Appendix 3

[14] M.E.D.: Directive of the European Parliament and of the Council on marine equipment

3. Opinion on the compass

Design

The compass is essentially of a very simple design, where use has been made of simple material selections and designs in order to maintain the MED standard for Class B lifeboat compasses in accordance with ISO 25862:2009. The compass type is designed and approved for lifeboats. The magnet system consists of bar magnets, a design that can exhibit more internal anomalies than the more costly systems with sintered ring magnets. See Figure 2.

On compass roses that do not have a float, the gravitational forces are not generally able to counteract the magnetic force of attraction caused by changes in the magnetic field when the compass is used globally. Instead of using a float to increase the compass rose's righting moment[15], balancing takes place with a counterweight. Thus, the balancing on this compass is optimal for a certain geomagnetic area.

We have not calculated stability or controlled these effects for this compass as we perceive that this, in light of what is established above, would fall outside the assignment.

In addition to the above control, the measurements suggest that the compass itself has fulfilled the minimum level described by the standard.

The air bubble and the burn-through that the compass lighting has caused has not affected the function to any decisive extent.

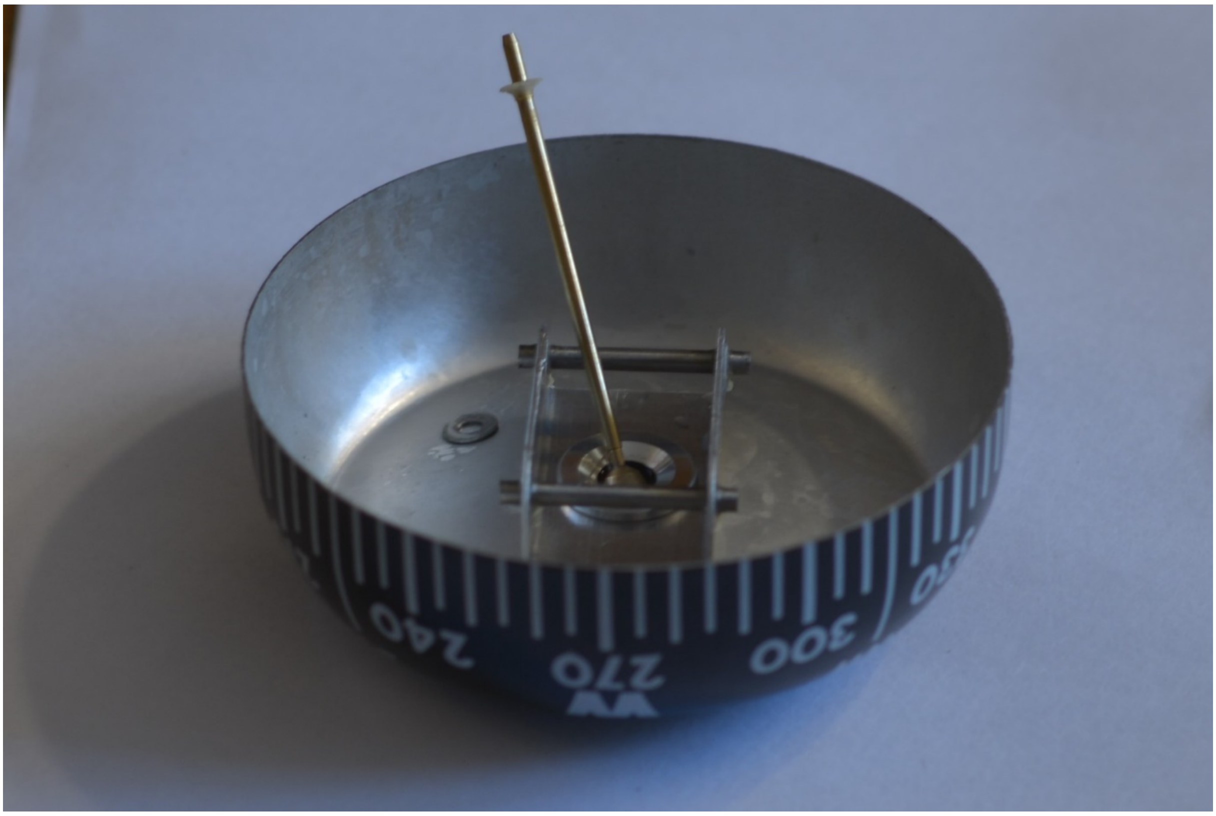


Figure 2. Compass rose with bar magnets, balance weight and suspension (pin and stone). The suspension shaft is secured with glue in its bracing on this compass model. Photo: SG GolfCon

[15] The float also decreases the gravitational force that the compass rose exerts on the suspension in the normal force direction.

Other observations

M.E.D. certificate (“wheel mark”) states, on page 2 of the certificate, conditions for the approval. One condition that is stated on several certificates is that the compass site shall be properly compensated. See appendix from another compass (Plastimo 135), which also specifies which geomagnetic area this type of simpler compass designs’ variants are intended for and that the compass type can be useful for vessel types other than lifeboats in accordance with the administration of the respective flag state. The Swedish Transport Agency does not appear to have a general rule to permit Class B lifeboat compasses instead of Class B compasses, for example, and the same seems to be true for the Polish authority.

<u>Example from an M.E.D. certificate's page 2 (see example from another make in Appendix 4):</u>

“4.APPLICATION/LIMITATION; 4.3 Each compass is to be properly compensated and its table or curve of residual deviations is to be available on board, in the vicinity of the compass, at all time.”

This also has support in SOLAS Ch V, R 19 under points 2.1.1 and 2.1.3, and applies to all vessels irrespective of size; thus also pleasure vessels unless otherwise expressly prescribed. Corresponding rules for Swedish vessels are stated in TSFS 2011:2 Ch 3, Section 5, point 1, which applies to “all vessels” except where otherwise stated[i]. The exceptions for a magnetic compass on Swedish vessels, by way of comparison, are only ports, rivers, canals and smaller lakes within sea area E.

In this context, it can be mentioned that the applicable standard ISO 25862:2009 also states this. The standard must be applied in its entirety in order for its purpose to be functional.

It has not been possible to find these specific conditions and requirements as the certificate/certificate reference has not been found for the marking stated for the relevant Class B lifeboat compass on MarED’s[16] control page for certificate status.

What we have also learned in connection with this control is that several manufacturers only choose to present page 1 and not the complete certificates on several manufacturers’ websites. Important information might thereby be withheld from a party which, for example, is planning to acquire or is planning to install a magnetic compass.

All vessels shall, in accordance with SOLAS Ch V, Annexes 13 and 20 and with ISO 25862:2009 Annex G, adjust the compass every other year (flag states have prescribed intervals between one and three years and if there is deviation from the deviation curve with more than one value; according to the mentioned ISO two degrees and by way of comparison for Swedish vessels, five degrees from the previous deviation table according to the general advice).

[16] MarED is the co-ordination group for the Notified Bodies assigned by the Member States to carry out the conformity assessment procedures referred to in the Marine Equipment Directive. www.mared.org

Opinion on the magnetic compass

The examination has shown that:

- The Autonautic compass, with some defects caused by an unclear reason, has conditions to function well in a geomagnetically limited area at a compass site that fulfils the ISO standard for a standard compass and probably the limited distances for a steering compass
- The design of the Autonautic compass is of a simpler model (bar magnets/suspension) whose intended geomagnetic area of use is unclear. The compass card will tilt noticeably[17] on magnetically southern latitudes.
- We have not succeeded in finding the applicable M.E.D. certificate for this Autonautic compass
- We cannot deduce whether a Class B lifeboat compass may according to the flag state be placed on vessels other than lifeboats
- IMO A.382 (also in ISO 25862:2009) safe distance to induced iron is not adhered to
- safe distance to instruments/marine equipment is not adhered to
- Neither inspection nor self-inspection has identified or noted and corrected the problems with the compass location and the consequences of these
- The conditions for following regulations and standards should be examined further.

Furthermore, it is probable that both vessel supervision/inspection would have been served if a competent compass adjuster or adequate training level at the shipping company/vessel had secured the three points below.

Of the three conditions that shall be fulfilled for a magnetic compass, the answer to SHK's enquiry is:

1. <u>M.E.D. certificate:</u>
   There are doubts concerning the formal approval and whether the compass type is considered approved for the vessel type by the flag state. The compass fulfils in practice the ISO requirements for a Class B lifeboat compass according to our measurement in the control station. The conditions should therefore have been conducive to the compass itself functioning reliably. From a functional perspective, the discussion on M.E.D. certificates is of minor significance. The certification has no real value in this case. However, the introduction of the European Marine Directive might have meant that the market has adjusted to the "minimum requirements" and there is reason to suspect that a focus on M.E.D. certificates instead of function has permeated the exercise of authority, supervision and thereby also the selection of compass.
2. <u>Requirements on compass site with regard to all types of disturbance/deviation:</u>
   The compass site has neither fulfilled requirements on distance to iron (mainly induced magnetism) nor instruments/equipment (mainly permanent magnets)
3. <u>Compass adjustment:</u>
   The Autonautic compass, which had a central compensation arrangement, was adjusted to compensate a combined disturbance of 55 degrees (Bi/Bp and Ci/Cp)[18]

[17] The angle has not been calculated or measured
[18] Fore-and-aft induced and permanent magnetism as well as athwartship induced and permanent magnetism

which gives an erroneous indication/deviation of reverse polarity when a compass without these correctors is placed at the compass location.

No notes on residual deviation (known as deviation table, deviation curve or other deviation information) have been found according to information from SHK's enquiries.

Summary opinion on the compass:

The decisive factor has been that the compass location has not been appropriate according to point 2. The matter of which compass is placed at the location has had less importance.

The vessel has in all probability sailed under the following two conditions:

a. an excessively “over-compensated” Class B lifeboat compass where the compass location has had such a poor or weak directive force that the heading indication has become unreliable
b. an uncompensated Class A compass with a large deviation/erroneous indication, where the unreliability consists of a non-documented severe deviation and an uncertainty consisting of a sharp gradient on the curve (one degree's real heading change shows several degrees’ change on the compass and vice versa; one degree's change on the compass is several degrees’ real heading change), which, with a deviation over 5 degrees (in this case 55º), gives an unreliable compass.

Test and analysis section

Address: SG GolfCon
Södergatan 62
274 34 Skurup
Control station and workshop
Tel: +46 (0) 411-459 87 / +46 (0) 70-360 56 88 +46 (0) 70-690 96 54
E-mail: sg.golfcon@tele2.se compass@tele2.se

Org Nr/VAT NO: SE 630 120 234 401

The “Möllerström model”

Measurement of deviation with the central compensation's setting in an undisturbed environment

<u>Observation and comment concerning A errors (coefficient A)</u>

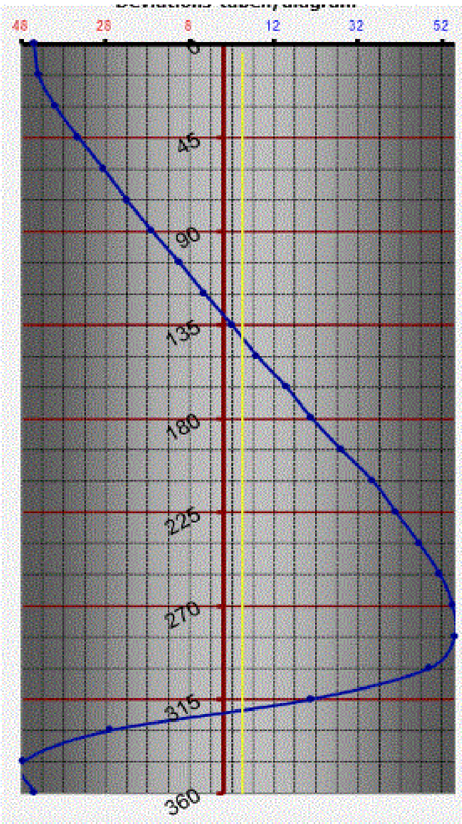
The measurement shows that the correctors, in the position they were in, yield an “A error” with the coefficient A = 4.4 degrees. The error that is normally associated and can be handled as an alignment error arises in this case from the asymmetry that the correction magnets create in the magnetic field. The error created by compensation magnets that are near the compass rose system may amount to a maximum of $(40/H)^{o}$, i.e. 2.2^{o} in the magnetic field that has been used in the test. (5.2.2.2)

See also the image of the central compensation in Appendix 5.

A further uncertainty in the analysis is reading errors resulting from the abnormally sharp gradient of the curve.

The Fourier series in the curve analysis yields in itself less convergences in these calculations at the decimal level. Rounding errors in the calculations have not been examined further. These errors are of subordinate character.

Provided that the deviation at the compass site for the steering compass has been removed or reduced to around zero with the above central compensation’s setting, a compass, at the same site, without the above correctors (removed correctors) will exhibit the curve on the next page with reversed values for the deviation.



K	Km	Kk	dev
003,6	000,0	045,0	-45,0
018,6	015,0	059,0	-44,0
033,6	030,0	070,0	-40,0
048,6	045,0	079,5	-34,5
063,6	060,0	088,5	-28,5
078,6	075,0	098,0	-23,0
093,6	090,0	107,0	-17,0
108,6	105,0	115,5	-10,5
123,6	120,0	124,5	-4,5
138,6	135,0	133,0	+2,0
153,6	150,0	142,0	+8,0
168,6	165,0	150,0	+15,0
183,6	180,0	159,0	+21,0
198,6	195,0	167,0	+28,0
213,6	210,0	174,5	+35,5
228,6	225,0	184,0	+41,0
243,6	240,0	193,5	+46,5
258,6	255,0	203,5	+51,5
273,6	270,0	215,5	+54,5
288,6	285,0	230,0	+55,0
303,6	300,0	251,0	+49,0
318,6	315,0	294,0	+21,0
333,6	330,0	357,0	-27,0
348,6	345,0	392,5	-47,5

Deviering med

Km 0

Kk 0

dev +

K 0

Koefficienter

A:	+4,4
B1:	-35,8
B2:	-33,8
C1:	-33,0
C2:	-20,2
D:	-4,1
E:	-15,4
F:	+1,0
G:	-6,4
H:	+0,00
K:	-2,0
J:	

Anteckningar Max 65 tkn

Figure 3. Deviations measured with the compass correctors mounted.
Source: SKJF control program

Probably exhibited deviations for a compass that is mounted at an uncompensated compass site

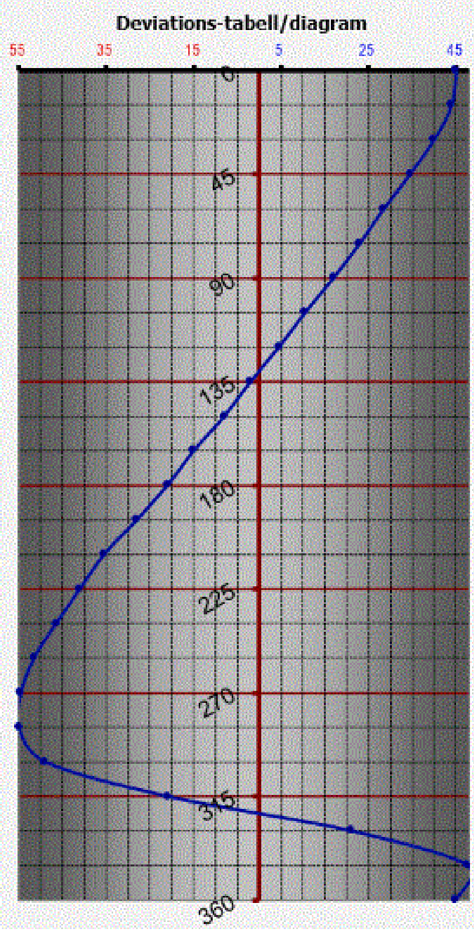
Comment: an exact placement of the Weilbach compass is required for absolute correspondence, which is only possible in theory. The analysis result shall therefore only be seen as a reasonable result.

Curve analysis

<u>Limitation:</u> This analysis is based only on the deviation obtained on the cardinal and intercardinal headings.

The curve's max gradient in the following secant(s), between Km: 315° and 360°.
Max dev-diff in secant(s) = 66.0°.
The curve's max gradient in the diagram, (prog): ~ 68.7°.
The curve's max gradient in the diagram, (print): ~ 65.4°.
The curve's max gradient, calculation with the derivative: = 55.7°.
The standard deviation = 34.64
The variance = 1199.7
The deviation is between -55.0° and +47.5°
Max dev-diff in the entire curve = 102.5°.

The curve does not correspond to the requirements in ISO 25862:2009 G.1 for any vessel.



K	Km	Kk	dev
003,6	000,0	315,0	+45,0
018,6	015,0	-029,0	+44,0
033,6	030,0	-010,0	+40,0
048,6	045,0	010,5	+34,5
063,6	060,0	031,5	+28,5
078,6	075,0	052,0	+23,0
093,6	090,0	073,0	+17,0
108,6	105,0	094,5	+10,5
123,6	120,0	115,5	+4,5
138,6	135,0	137,0	-2,0
153,6	150,0	158,0	-8,0
168,6	165,0	180,0	-15,0
183,6	180,0	201,0	-21,0
198,6	195,0	223,0	-28,0
213,6	210,0	245,5	-35,5
228,6	225,0	266,0	-41,0
243,6	240,0	286,5	-46,5
258,6	255,0	306,5	-51,5
273,6	270,0	324,5	-54,5
288,6	285,0	340,0	-55,0
303,6	300,0	349,0	-49,0
318,6	315,0	336,0	-21,0
333,6	330,0	309,0	+21,0
348,6	345,0	297,5	+47,5

Deviering me

Km
Kk
dev
K

Koefficienter

A:	-4,7
B1:	+35,8
B2:	+33,8
C1:	+33,0
C2:	+20,2
D:	+4,1
E:	+15,4
F:	-1,0
G:	+6,4
H:	+0,00
K:	+2,0
J:	

Anteckningar Max 65 tkn

Figure 4. The curve and the table describe the deviations that the compass location should have once the correctors have been removed. Source: SKJF control program

Deviation of the fore-and-aft magnetism

Cause: Asymmetrically placed fore-and-aft magnets and/or induced magnetism in vertical iron present fore or aft of the compass makes the field inhomogeneous.

The fore-and-aft magnetism gives a deviation of 35.8°.

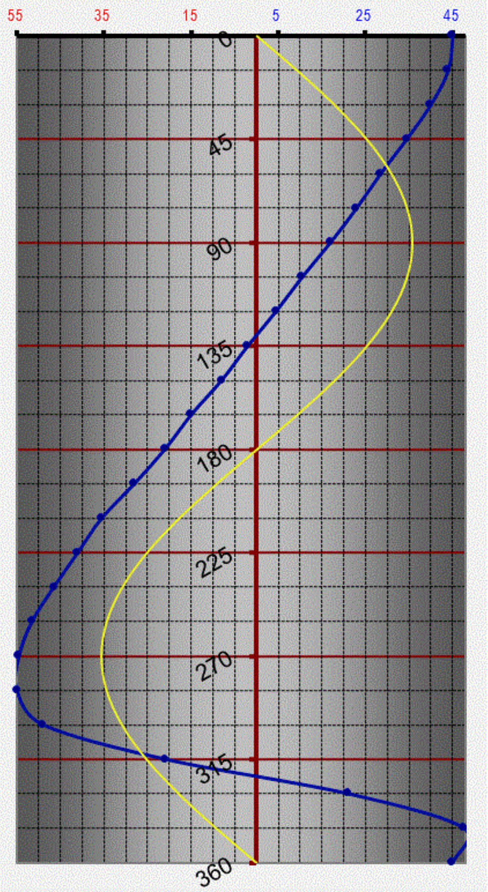


Figure 5. The split deviation for the fore-and-aft magnetism [B] of the compass site (Yellow curve). Source: SKJF control program

Deviation of the athwartship magnetism

Causes: Asymmetrically placed athwartship magnets and/or induced magnetism in vertical iron, present starboard or port of the compass, makes the field inhomogeneous.

The athwartship magnetism gives a deviation of 33.0°.

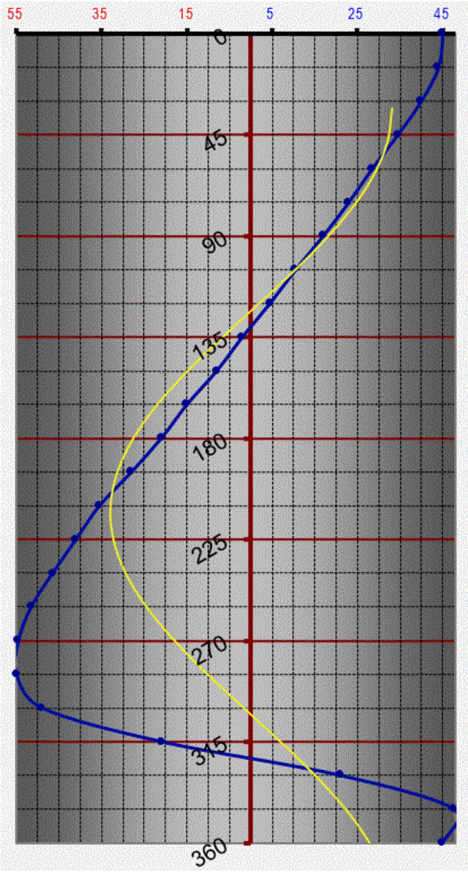


Figure 6. The split deviation for the athwartship magnetism [C] of the compass site (yellow curve).

Source: SKJF control program

Analysis comparison against photo

In addition to the causes of the fore-and-aft and transverse magnetism, the analysis also yields the following:

- Symmetrically placed soft iron is present as +A iron.
- The soft iron consists partly of fore and aft-placed A iron and partly of transverse A iron.
- With +A iron, there is interrupted fore and aft iron, which results in four poles, two of which are next to the compass.
- With +E iron, there is interrupted transverse iron, which results in four poles, two of which are next to the compass. Continuous transverse iron is the most common, yielding – E iron.
- There is asymmetrically placed horizontal iron, + B iron and + D iron

When the quadrantal deviation’s effect on the curve’s appearance and coefficients cannot be established without swinging the vessel, the uncertainty is too great for mathematically analysing the induced effect.

However, it is indisputable that an attempt has been made to compensate the combined permanent and induced athwartship and fore-and-aft deviations.

Figure 7. The steering position seen obliquely from port. Photo: SHK   *Figure 8. The steering position seen obliquely from starboard. Photo: SHK*

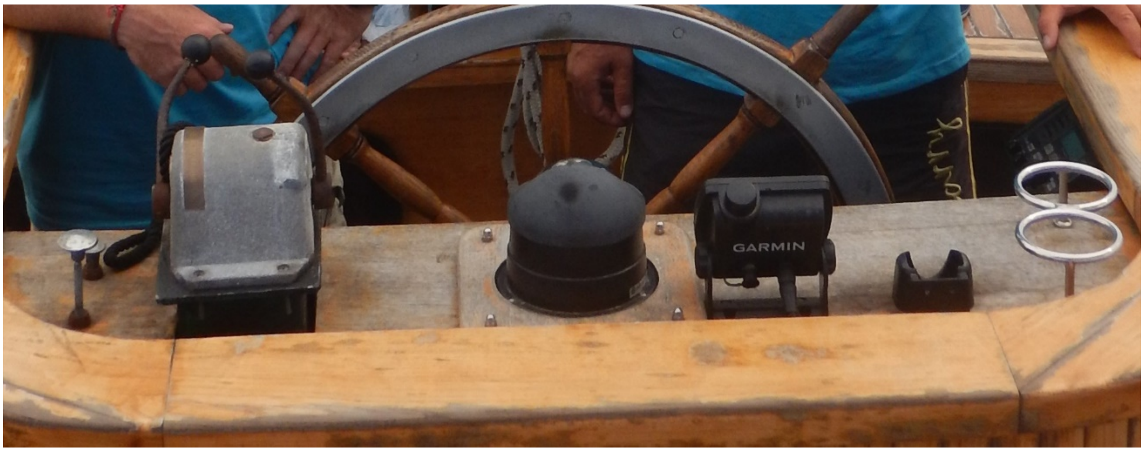


Figure 9. The steering position seen from forward. Photo: the owner through SHK

The built-in erroneous indication and characteristics of the compass

In the context, the errors that occur are marginal and derive from the manufacturing process: eccentricity and collimation errors[19] in the compass system and the degree dial's manufacturing tolerances. The reading error in this test is deemed less than 0.2 degrees.

The errors occurring in the reading for 135° and for 270° are included in the previous analysis series and can affect the analysis result. A corrected analysis shows that the errors have only affected previous results very marginally.

The measured values lie within the tolerances forming the basis for the M.E.D. approval (ISO 25862:2009; 4.5 Accuracy; 4.5.1 Directional error), where these errors may amount to a maximum of 1.5° for a Class B compass.

Km	dev
000,0	+0,0
015,0	+0,0
030,0	+0,0
045,0	+0,0
060,0	+0,0
075,0	+0,0
090,0	+0,0
105,0	+0,0
120,0	+0,0
135,0	-0,5
150,0	-1,0
165,0	-0,5
180,0	+0,0
195,0	+0,0
210,0	+0,5
225,0	+0,0
240,0	+0,5
255,0	+0,5
270,0	-0,5
285,0	+0,5
300,0	+1,0
315,0	+0,0
330,0	+0,0
345,0	+0,0

Table 1: SKJF control program
Test results according to ISO 25862:2009
4.5.1. Directional error

Other test facts

Governing document: ISO 25862:2009.

Annex H on life and rescue vessel compasses.

Only remarks reported below.

Checks carried out:

Chapter 4

4.1.2, 4.1.6 a–d and f–g.

4.1.6 e one remark: bubble poss. leak. *

4.3.4, 4.4.1, 4.5.1 (see table), 4.5.3, 4.5.4 alternative method of measurement.

Expanded test:

4.3.3. was performed in addition to the test requirements for lifeboat compasses in order to compare the magnetic moments of the compasses.

** 4.1.6 tests were carried out at $20^{\circ}C$to avoid the risk of breaking the damaged glass before photo documentation of interior*

[19] Line of sight-reading-suspension axis

The errors have been rounded to the nearest half degree.

Appendix 1

Explanation of components

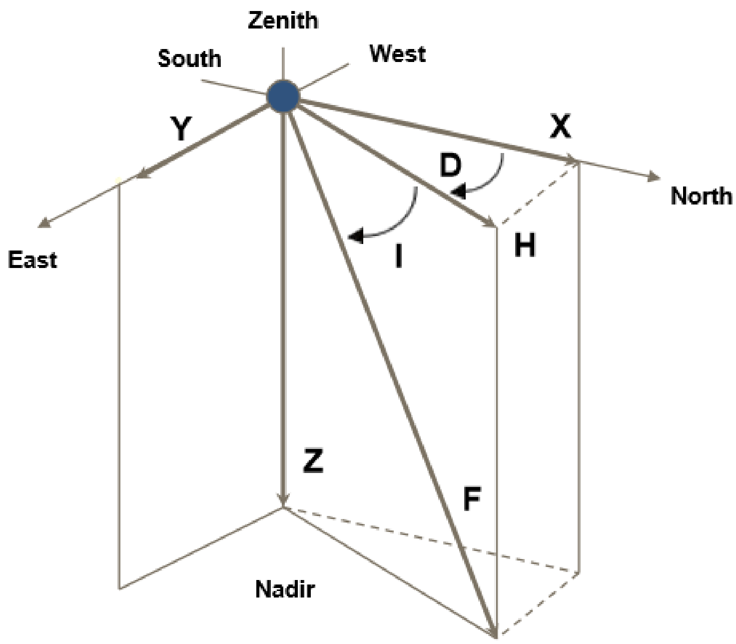


Figure 1: The seven elements of the geomagnetic field vector B_m associated with an arbitrary point in space.

The expected magnitudes of the Earth's magnetic field

Table 1: Ranges of magnetic elements and *GV* at the Earth's surface.

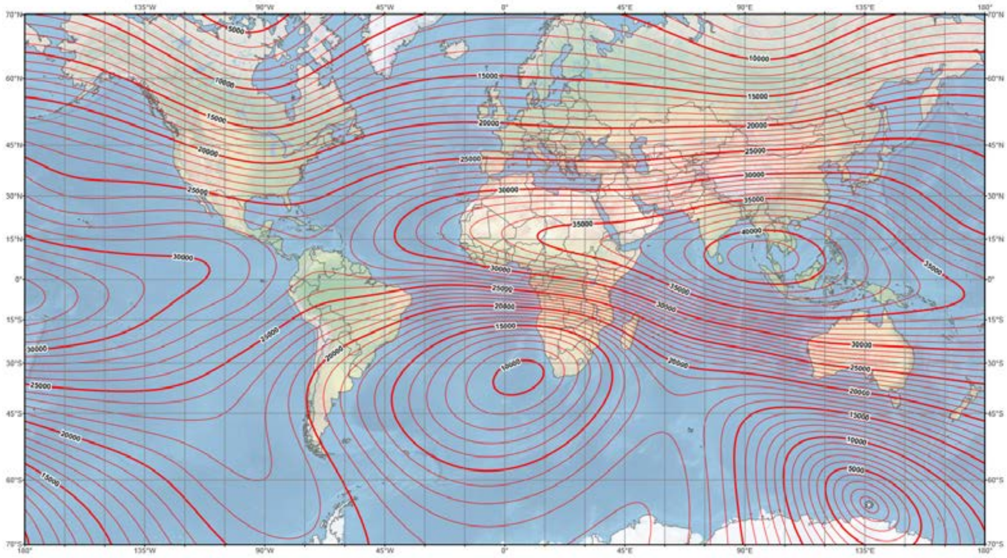
Element	Name	Alternative Name	Range at Earth's Surface			Positive Sense
			Min	Max	Unit	
X	North component	Northerly intensity	-17000	42000	nT	North
Y	East component	Easterly intensity	-18000	17000	nT	East
Z	Down component	Vertical intensity	-67000	61000	nT	Down
H	Horizontal intensity		0	42000	nT	
F	Total intensity	Total field	22000	67000	nT	
I	Inclination	Dip	-90	90	Degree	Down
D	Declination	Magnetic variation	-180	180	Degree	East / Clockwise
GV	Grid variation	Grivation	-180	180	Degree	East / Clockwise

Source: NOAA®

Appendix 2

Overview maps of the horizontal [H] and vertical [Z] intensity of the Earth's magnetic field

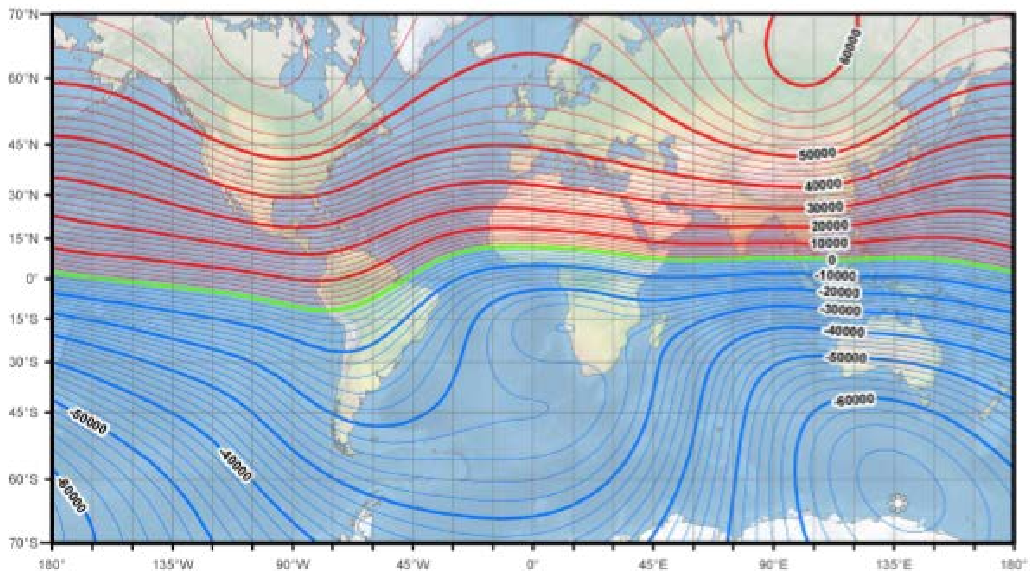
Main Field Horizontal Intensity (H)



Main field horizontal intensity (H)
Contour interval: 1000 nT.
Mercator Projection.
: Position of dip poles

Map developed by NOAA/NGDC & CIRES
http://ngdc.noaa.gov/geomag/WMM
Map reviewed by NGA and BGS
Published December 2014

The vertical field



Main field down component (Z). Contour interval is 1000 nT, red contours positive (down); blue negative (up); green zero line. Mercator projection.

Source: NOAA®

Appendix 3

Reference number: C15 - 0049

Design Features

- 100 mm conical card
- 5° graduation
- Anti-glare screen
- 12/24 V Lighting
- Type MED/SOLAS approved
- 5 years warranty
- Compensation built-in
- Repairable

AUTONAUTIC NSTRUMENTAL, S.L.
Italia, 1
08320 EL MASNOU
SPAIN
PH: +34.93.540.9949
info@autonauticinstrumental.com

Deck mount compass 100 mm flat card - Black

Power and Sailing boat

0474/YY

Download type approval here

RINA 150 YEARS

Source: https://autonauticinstrumental.com/

Appendix 4

Example of certificate from another manufacturer

MARINE DIVISION

Certificate number: 14300/B1 EC
File number: NAV 10/1092/12
Annex A1 Item number: A.1/4.23

This certificate is not valid when presented without the full attached schedule composed of 7 sections

www.veristar.com

Notified Body 0062 - MARINE EQUIPMENT DIRECTIVE 96/98/EC

EC TYPE EXAMINATION CERTIFICATE

as per Module B of European Union Council Directive 96/98/EC on marine equipment
as amended by Commission Directive 2010/68/EU

This certificate is issued to

PLASTIMO Marine
LORIENT - FRANCE

for the type of product

COMPASS FOR LIFEBOATS AND RESCUE BOATS
Type: OFFSHORE 135, conical card - CLASS B.
"Also suitable for sailing boats, motor sailing vessels and larger motor yachts"

Requirements:
SOLAS 74 Convention as amended, Regulations III/4, III/34 and X/3,
IMO Resolution MSC.97(73) (2000 HSC Code) 8 and 13,
IMO Resolution MSC.48(66) (LSA Code) IV, V,
ISO 25862 (2009).

This certificate is issued under the French Maritime Authority to attest that BUREAU VERITAS did undertake the relevant type-examination procedures for the product identified above which was found to comply with the relevant requirements of the Council Directive 96/98/EC of 20 December 1996 as amended.

This certificate will expire on: 19 Jan 2015

For BUREAU VERITAS Notified Body 0062,
At BV NANTES, on 12 Mar 2012,
Joel Gaurin

BUREAU VERITAS SURVEYORS AT PARIS 1828 NANTES INTERNATIONAL REGISTER

This certificate does not allow to issue the Declaration of Conformity and to affix the mark of conformity (wheelmark) to the products corresponding to this type. To this end, the production-control phase module (D, E or F) of Annex B of the Directive is to be complied with and controlled by a written inspection agreement with a notified body.
This certificate remains valid until the date stated above, unless cancelled or revoked, provided the conditions indicated in the subsequent page(s) are complied with and the product remains satisfactory in service. This certificate will not be valid if the applicant makes any changes or modifications to the approved product, which have not been notified to, and agreed in writing with BUREAU VERITAS. Should the specified regulations or standards be amended during the validity of this certificate, the product(s) is/are to be re-approved prior to it/they being placed on board vessels to which the amended regulations or standards apply. BUREAU VERITAS is designated by the French Maritime Authority as a "notified body" under the terms of the French Regulations Division 140 Chapter 140-2. This certificate is issued within the scope of the General Conditions of BUREAU VERITAS Marine Division available on the internet site www.veristar.com. Any Person not a party to the contract pursuant to which this document is delivered may not assert a claim against BUREAU VERITAS for any liability arising out of errors or omissions which may be contained in said document, or for errors of judgement, fault or negligence committed by personnel of the Society or of its Agents in establishment or issuance of this document, and in connection with any activities for which it may provide.

THE SCHEDULE OF APPROVAL

1. PRODUCT DESCRIPTION:

Magnetic Compass - Class B

Type: OFFSHORE 135, Conical Card.

Manufacturer's designations:
- 23484 - 23493 Zone A
- 23485 - 23494 Zone B
- 23486 - 23495 Zone C
- 23487 - 23496 Zone BC.

2. DOCUMENTS AND DRAWINGS:
In accordance with manufacturer's documents:
- Drawings N°s:
  23484, 42801, 42585_2, 42469_1, 17664_1, 23761249/50, 23761256_57, 1676_5, 23761263, 3913, 23761333, 24641, 11615, 15725, 22667802_4, 22680907_2, 23479, 23481_5, 23761201_6, 23761218_12, 23761225_3, 23791078_5, 23791097_1, 23791103, 29200207, 25956_2, 23761232, all dated 25/05/04.
- CALAMIT statement ref. 010511/4 dated 11/05/2001 & 040610/J1 dated 10/06/2004.

3. TEST REPORTS:
3.1 - Test reports N°s: E020943-3 & E020943-4 dated 04/10/2004 issued by LCIE - France (Laboratoire Central des Industries Electriques).
3.2 - Test reports N°M030764-3 dated 16/11/2011 and issued by LNE - France (Laboratoire national de métrologie et d'essais).

4. APPLICATION / LIMITATION:
4.1 - As per requirements of regulations stated on the front page of this certificate.
4.2 - Also suitable for sailing boats, motor sailing vessels and larger motor yachts, in agreement with the Administration whose flag the vessel is entitled to fly.
4.3 - Each magnetic compass is to be properly compensated and its table or curve of residual deviations is to be available on board, in the vicinity of the compass, at all time.
4.4 - Each MAGNETIC COMPASS intended to be fitted on board Lifeboats, rescueboats, sailing boats, motor sailing vessels and larger motor yachts shall be delivered with a Declaration of Conformity, which shall be signed by the manufacturer.

5. PRODUCTION SURVEY REQUIREMENTS:
This certificate does not allow the applicant to issue the Declaration of Conformity and to affix the mark of conformity (wheelmark) to the products corresponding to this type. To this end, the production-control phase module D "Production Quality Assurance" or E "Product Quality Assurance" or F "Product Verification" of Annex B of the Directive is to be complied with and controlled by a written inspection agreement with a Notified Body.

6. MARKING OF PRODUCT:
6.1 - Compasses are marked in a conspicuous place on the compass card with the name of the manufacturer.
6.2 - Compasses shall bear the type identification or a reference number.
6.3 - The type of liquid used, if other than alcohol, shall be marked on the bowl in the vicinity of the filling plug. If the compass is sealed, a label shall state "this compass cannot be re-filled".
6.4 - Markings as per MED 96/98/EC:

YYYY/XX where YYYY is the number of the Notified Body undertaking surveillance module (when BV, 0062) and where XX are the last two digits of year mark affixed.

7. OTHERS:
7.1 - This approval is given on the understanding that the Society reserves the right to require check tests to be carried out on the Magnetic Compass at any time, and that **PLASTIMO, Lorient - FRANCE** will accept the responsibility for informing shipbuilders or their sub-contractors of the proper methods of use and general maintenance of the Magnetic Compass and the conditions of this approval.
7.2 - This certificate supersedes the Type Approval Certificate N° 14300/B0 EC issued on 19/11/2011 by the Society.

*** END OF CERTIFICATE ***

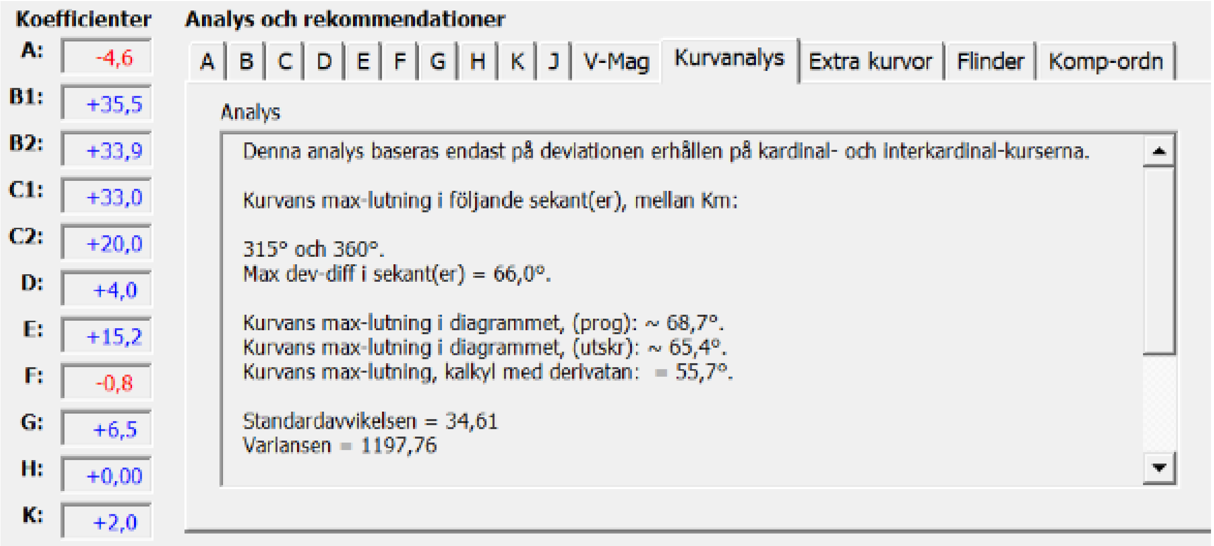
Appendix 5

The central compensation device on the examined compass. View from below. Image: SG GolfCon

Appendix 6

Recalculation of mathematical analysis excluding the built-in erroneous indication of the compass. Corrected headings: 135º and 270º

The errors affect the analysis very marginally and are completely irrelevant to the final result.



Source: SKJF control program