# New Zealand Naval Architect

The newsletter of the New Zealand Division of the Royal Institution of Naval Architects Issue 30 •Jan 2008


## A New Concept for Lightning Protection of Boats

### *Protect a Boat like a Building*

By

Ewen M. Thomson, Ph.D.

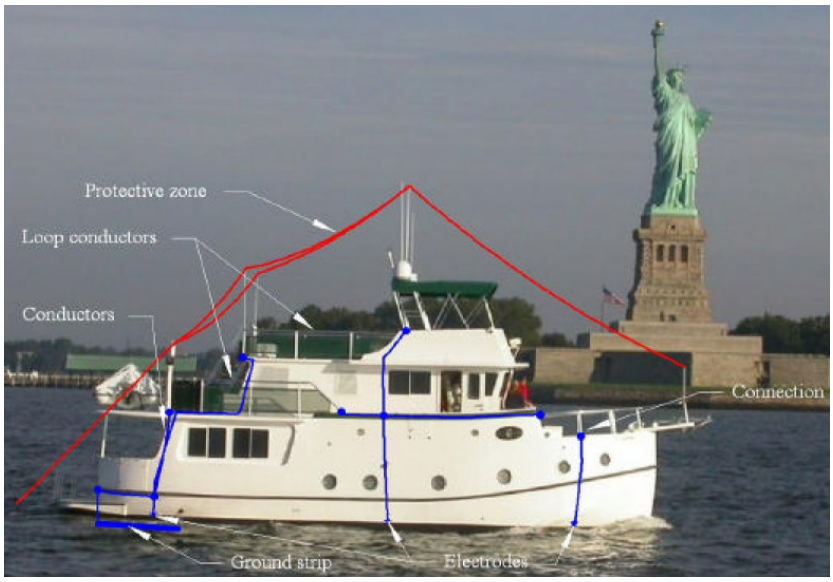


Figure 1—the John Henry (Great Harbour 47' passagmaker)

"A Critical Assessment of the US Code for Lightning Protection of Boats" was the title of a paper published in 1991 by the Institute of Electrical and Electronic Engineers (IEEE). This peer-reviewed journal publication pointed out several key problem areas existing in standards published by all major authorities concerning lightning protection of boats. Some, such as upgrading the size of a main lightning conductor from 8AWG to 4AWG, required minor editorial changes while others were fundamental issues that had no clear solution. A major issue was the conclusion that "a 1-sq ft ground plate is shown to be hopelessly inadequate to prevent sideflashes in fresh water". In 1991 there was no practical solution for this. Stretching the grounding area into a long strip improves its theoretical performance but is difficult to implement. Another concern, which also gives a hint to the solution, becomes evident when we compare lightning protection techniques used successfully in

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## INSIDE



## A Word from the President

Hello fellow members and a Happy New Year to you all.

The New Zealand Division has done well in the past nine months meeting our objectives in the areas of:

Continuous professional development, with very well attended course by Cleandons on Copyright Law and on Marine Structures and Stability, two courses run by John Harrhy Consulting Ltd. I would like to thank James Carnie and John Harrhy for their efforts in arranging and delivering the courses

Very successful Industrial visits to Alloy Yachts, Yachting Developments. I would like to thank the companies for their hospitality and I would also like to thank Roger Hill and Jarrod

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Hall for their efforts in making the visits such a success and helping to further the division's relationship with the marine industry.

The Institution awarded the RINA / VT Fitzroy prize at the Auckland University school of Mechanical Engineering to Henry Alasdair Donald and Joseph Reindler for their project **"A Study of the Aerodynamics of the Olympic Variant Tornado Class Catamaran"**.

I would like to thank VT Fitzroy and their Managing Director Mike Wardlaw for their continued support. The Division is actively looking for industry sponsors to help with the establishment of RINA prizes in association with other academic institutions.

We have also had our inaugural meeting of the Massey University School of design advisory board and members of council have also continued to work with the school of design in the judging of the final year student projects.

We plan to build on the good work in the areas of continued professional development of members and developing and strengthening further our links with both the academic and industrial sectors in New Zealand, with a view to providing both prizes and scholarships.

To make this possible the institution needs the support of industry and its members to remain strong and vibrant in order to achieve our aims. I would like to ask members to consider how they can contribute to achieving our aims and I would like to hear from any member who would be willing to sit on the council to help maintain and further the good work of the division's council members.

I wish you all a prosperous and successful 2008.

buildings with those typically applied, with much less success, to watercraft. In buildings the lightning conductors are placed on the outside and terminate in multiple ground rods, also on the outside. On the other hand, the requirement that only one ground plate is called for in a boat usually results in a single down conductor running through the middle of the boat. With 20:20 predictability, internal side flashes frequently form between conductors in the lightning protection system and other conducting fittings. These internal side flashes can be prevented by bonding the fittings to the lightning protection system, as mandated in the standards, but bonding also increases the risk of external side flashes from the fittings to the water.

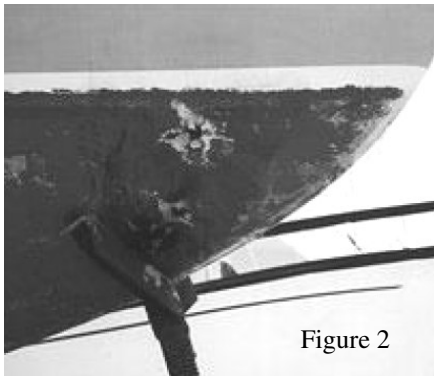

Figure 2

The obvious organization to address these problems is the American Boat and Yacht Council (ABYC,) whose marine standards form the basis for National Marine Manufacturers Association (NMMA) certification. In recognition of the above problems inherent in the Lightning Protection Standard E-4, in its latest rewrite ABYC downgraded it to a Technical Report. However, even when the standard E-4 existed, it was not required for NMMA certification. During its latest revision cycle, the National Fire Protection Association (NFPA) has taken on a comprehensive rewrite of their lightning protection standard for watercraft based on the simple concept that the lightning protection system on a boat should resemble that on a building. The NFPA standard is reviewed on a four-yearly cycle by a committee of lightning protection professionals and contains not only the code but also several informational annexes explaining the underlying principles. The result in Chapter 8 of NFPA780-2008 is a new watercraft standard. Instead of a single lightning rod (air terminal) at the top of a centrally located mast, many air terminals may be placed around the perimeter. Instead of a single down conductor following the straightest path to the water, an interconnected grid of down conductors are placed externally to fittings, crew and electronics. Instead of a single one-square-foot immersed ground plate, multiple grounding terminals terminate the down conductors, also preferentially externally.

## Problems with previous standards

While there were a number of problems with the status quo (before NFPA780-2008), the major stumbling block was the mandate for a one square foot ground plate or strip. This was frequently interpreted to mean that

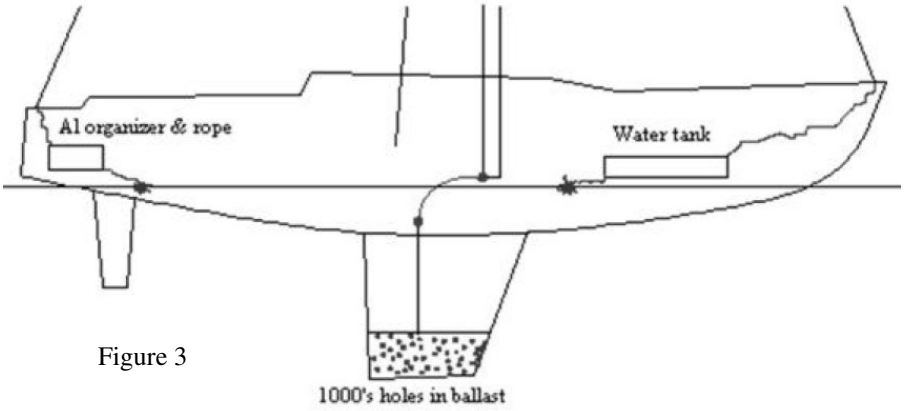


Figure 3

that was all that was required and the best way to connect this was by the shortest path possible to a single air terminal on top of a mast. In the 1991 IEEE paper I calculated what typical voltage the lightning protection system would reach if it were connected to a single immersed grounding conductor with a contact area of one square foot. In fresh water this voltage was found to be so large that sideflashes would be inevitable. (A side flash is an uncontrolled spark that carries current to the water and can do extensive damage to hulls and equipment.) This calculation was done to help explain observations of extensive sideflash damage in sailboats even when the mast was grounded to the keel or a ground plate. Cases such as that seen in figure 2 have necessitated a new term to be added to the glossary of lightning protection - a "supplemental grounding electrode" that conducts lightning current into the water in addition to that conducted by a main grounding electrode (or ground plate). In this case the anchor chain formed sideflashes through the hull causing extensive hull damage.

In another case, see figure 3, a water tank and an aluminium organizer acted as supplemental electrodes. The owner of this sailboat reported not only "thousands of holes" in the lead ballast- indicating that lightning current had indeed flowed out of the intended grounding conductor - but also noted two large holes at about the waterline and outboard of an aluminium organizer aft and a water tank forward. The side flashes that caused these holes originated, respectively, on the backstay and forestay and clearly took much longer and more tortuous paths than the shortest distance to the water. Apparently lightning does not always take the straightest path to the water, but rather has an affinity for the waterline. Note the major role of the two intermediate conductors (the organizer and the water tank) in guiding the side flash on its way to the waterline. It does not take much imagination to appreciate the probable consequences if a crew member had been lying in the V berth between the forestay chain plate and the water tank.

When a side flash does occur through a fibreglass hull, carbon atoms are split out of the resin, thereby weakening the laminate, and this residual carbon now forms conducting paths through otherwise insulating fibreglass. So if the boat were to be struck again it is highly likely that the carbon traces would provide attractive current pathways but their high resistances would likely result in overheating. In other words, the risk for serious hull damage is increased if the carbon is not removed during repairs. Thus removal of all carbon tracks should be a high priority during the repair of any fibreglass hull damaged by lightning. Unfortunately, finding and repairing these traces is often problematic, but if there is a side flash exit from the hull, you can be sure there are carbon traces present. So, theoretically, one square foot is not nearly enough. However, the illustration above shows that even the area of the lead ballast was not enough in this case. Apparently the problem is not so much the size of the grounding area but how it is distributed. Rather than attempting to dissipate the lightning current through just one ground plate, we need multiple exit points. The preferred locations for these, as indicated from observed exit holes, are around the outside of the hull rather than directly below the mast. The single ground plate is not the only major problem. The short, straight connection from mast base to the ground plate is another. This places the lightning charge right in the middle of the boat, increasing the risk of internal side flashes to intermediate conductors on the boat. In this respect, electrical wiring, water tanks (whether metal or plastic), and crew members are all possible

conductors.

### NFPA standard: Protect a boat like a building

The standard for buildings has been around for a long time, it has undergone many iterations and works very well. The difference is that the building standard places multiple lightning rods, conductors and grounding rods on the outside of the building. Maybe we can do something similar for boats?

The existing standard was examined with the intention of changing the fundamental concepts to be more in line with those applied to buildings. The result is a major departure. The final text is a comprehensive treatment of a whole lightning protection system, which includes details such as how to use existing fittings as part of the system and introduce spark gaps to minimize galvanic corrosion and electrolysis. There are three main differences between the standards.

### 1. Multiple air terminals

When determining where air terminals should be placed, any method that is allowable for buildings can now be used for boats. Instead of having to use just the cone of protection method to establish the protective zone, the rolling sphere method can be used. This allows air terminals to be placed around the perimeter and results in much shorter lightning rods being required. For example, in a powerboat with a T-top, the inverted cone when hung off the T-top gives a zone of protection that usually does not cover the whole foredeck. If instead we use the rolling sphere method, we can add an air terminal on the bow pulpit, such as a metal flag staff, so that the foredeck is now included. As long as the forward air terminal is higher than head height, the theoretical zone of protection now covers anyone working the foredeck. An even better approach is to string a catenary wire between the T-top and the air terminal as an overhead conductor provides far superior protection to a vertical rod.

### 2. External lightning conductors

Consistent with the building standard, lightning conductors (note the plural) are placed preferentially on the outside of the boat. What this does is establish a protective shield, somewhat similar to a Faraday cage, around the interior of the boat. Inside of this shield everything is at about the same voltage as the lightning protection system even if there is no bonding connection. In the new NFPA standard a novel feature is a loop conductor that completely encircles the boat. This serves as a conducting backbone for the conductor network, allowing air terminals and grounding terminals to be interconnected, as well as establishing this protective shield around the interior of the boat. The loop conductor serves the same function as the equalization bus in the old standard and replaces it. While equalizing potentials through bonding is a good idea, bonding conductors can also initiate side flashes. And the old mandate in Section 8.6.1.3 in the 2004 version of NFPA780 that “The equalization bus shall be connected to the underwater lightning grounding strip at both ends” virtually guaranteed that the bus would be centrally located and well below the waterline, two conditions that increase side flash risk. Instead,

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the new standard in Section 8.4.3.1 states "A main size loop conductor shall be routed … to form a continuous conducting loop outboard of crewed areas, wiring and electronics". Placing the loop conductor well above the waterline, outboard, and with grounding terminals below it retains the advantages of the equalization bus while correcting for its weaknesses.

### 3. Grounding terminals near waterline & around perimeter

The multiple lightning conductors coming down the outside need to be terminated in multiple grounding terminals, preferably close to the waterline. Distributing the down conductors and grounding terminals uniformly around the hull promotes current flow away from the boat. This minimizes voltage differences in the water below the boat and hence considerably reduces the risk of sideflashes from conducting fittings, even those that are close to the water.

This poses several practical problems if the only allowable type of grounding terminal is a one square foot immersed ground plate or strip. It is difficult enough to convince someone to bore holes through the hull below the waterline for installing even one immersed ground plate, let alone many. Doing this would appear to increase the risk of sinking after a lightning strike rather than decreasing it. In particular, if there has been any water leakage through these holes a steam-boiler type explosion is distinctly possible. So, if one is a problem, "multiple" compounds this to the point of infeasibility. And what about the old requirement that the ground plate should always be immersed? If a sailboat heels or powerboat comes to a plane the ground plate can become airborne.

So when the new standard mandates multiple grounding electrodes this could cause serious implementation problems. Note that "grounding electrode" is NFPA's new term for a grounding terminal in that it is a conductor through which current is passing at the interface between the lightning protection system and the grounding medium (water here). Fortunately, the damage we showed earlier indicates that lightning does not necessarily share this preference for immersed grounding conductors. In fact, the corners of water tanks, plumbing fixtures, metallic fittings and anchor chains seem to work just as well, and frequently much better. The same is true for immersed conductors such as metallic through hulls and propeller shafts that may have contact areas much less than one square foot. The waterline is a very popular target for sideflashes, and multiple exit points are the norm, especially in fresh water.

Recognizing that onboard fittings frequently act as inadvertent grounding electrodes, we have introduced the idea of a supplemental grounding electrode, one that has a contact area of less than one square foot, including zero. The standard still requires at least one 6 main grounding conductor with an immersed area of at least one square foot, but now smaller additional grounding terminals are also allowed. This makes it feasible to install multiple grounding terminals using existing metallic fittings such as through-hulls, propeller struts, and rudder posts even those with contact areas less than one square foot. Alternatively, smaller fittings specifically designed to act as grounding electrodes can be added, as we have done for John Henry below. Note that ABYC TE-4 also allows that "Rudders, external ballast keels, or any metallic fitting with at least one external face can be used for supplemental grounding so long as they meet other requirements in this bulletin… ".

### Lightning protection system on John Henry

These concepts have been applied on John Henry, a Great Harbour 47' passagemaker. See figure 1. It shows the main system features. The red lines show the total zone of protection using the rolling sphere method. Any person walking anywhere on the deck is inside this protective zone. In order to achieve this coverage we placed air terminals on the bow pulpit, on top of the fly bridge arch, and on top of the handrails at the rear of the fly bridge deck. The dinghy davit was also connected the to the lightning protection system. The blue lines show the additional lightning conductors which were made of 2AWG tinned copper marine battery cable. These were connected to existing conducting fittings - the handrails on both main and fly bridge levels, and the bimini – to form two conducting loops, one around the main deck level and the other around the fly bridge deck. Down conductors connected to these loop conductors were run vertically down the inside of the hull and terminated at SiedarcTM grounding electrodes at six locations symmetrically distributed around the waterline. The patented SiedarcTM electrode is a customized fitting designed specifically for lightning grounding. Each of these was installed just above the black stripe. One square foot of immersed grounding area was provided by a grounding strip placed near the stern of the boat.

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# "COPYING" vs UTILISING CREATIVE CONCEPTS: WHEN IMITATION BECOMES UNLAWFUL FLATTERY

By

James Carnie and Kara Wilton

It has long been established that copyright laws protect the expression of an idea, but not the idea itself. For example, the use of rudders or sails could never be reserved to one boat designer only. However, one designer can prevent another from copying their designs or, as the case may be, copying specific design elements.

So, what amounts to copying a work, as opposed to merely being inspired by another's work?

**Application of Copyright Laws**

Infringement by copying is the most commonly relied-upon ground of infringement of copyright. The Copyright Act 1994 defines "copying" broadly. "Copying" includes:

- Reproducing or recording work in any material form;
- Storing a literary or artistic work in any medium by any means; and
- The making of a copy in 3 dimensions of a 2-dimensional work and the making of a copy in 2 dimensions of a 3-dimensional work.
- Copying a "substantial part" of a work is, for the purposes of copyright infringement, the same as copying a work. Most case law in this area is about whether or not someone has copied a "substantial part" of a work.

In a leading case on this issue – the *Wham-O* case – the Court of Appeal adopted a three-fold approach to whether or not a work has been copied:

The reproduction must copy either the entire work or a substantial part;

There must be sufficient objective similarity between the infringing work and the original work, or a substantial part of the original work; and

There must be some causal connection between the original work and infringing work. In other words, the infringing work actually has to be derived – consciously or subconsciously – from the original work.

It can be quite difficult to apply these criteria in practice. Several leading Court decisions have held that it is the *quality* of what has been adopted from an original work, not the *quantity* that dictates whether work has been copied. However, the physical nature of artistic works means that it is more likely that the works can simply be viewed side by side and compared.

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This placement allowed the down conductor to this strip also to be run down the inside of the hull, external to all conducting fittings and equipment. As an additional precaution, all through bolts for the grounding strip were contained inside a watertight lazarette. The cost of such an installation is around US$6000-US$7000. John Henry has not been struck by lightning yet so that the effectiveness of this system has not been tested. And while John Henry's owner may hope the boat is never hit, we would find such a strike would add tremendously to current data!

**References**

1. "A Critical Assessment of the US Code for lightning Protection of Boats" by E.M. Thomson, IEEE Trans EMC, Vol.3, pp.132-138, 1991

2. TE-4 Lightning Protection, 2006 edition, ABYC,

3. NFPA 780-2008 Standard for the Installation of Lightning Protection Systems 2008 Edition,

*Ewen Thomson is founder of Marine Lightning Protection Inc. (www.marinelightning.com),. His Ph.D. is in Electrical Engineering and he has nearly three decades of experience as a lightning researcher and university instructor, including 20 years at the University of Florida. The main author of the revision that led to NFPA780-2008, he was also involved in the development of ABYC TE-4.*

*Ewen will be in New Zealand in February and the division hopes that Ewen will spare us the time to give a talk.*

## The Da Vinci Code Case

Last year's judgment in *Baigent and Leigh v Random House Group Limited* has provided a further valuable insight into the application of copyright laws to an allegation of "copying". Baigent and Leigh brought a case against Dan Brown's publishers for alleged copying from their 1982 publication, entitled "*The Holy Blood and Holy Grail*", and incorporation of aspects of that work in "*The Da Vinci Code*" (for example, by using "central themes" and theories present in the earlier work).

The Court dismissed the claim, ruling that "*The Da Vinci Code*" was an expression of a number of facts and ideas which were not protected by copyright. The Court accordingly affirmed that ideas and facts alone are not capable of being protected; rather, it is the way in which they are expressed or presented that may attract copyright protection. If Baigent and Leigh had been able to establish that Dan Brown had copied a qualitatively substantial part of their work, they may have been successful in their action against Random House.

## Implications for Designers

It is common practice in all industries to use concepts, precedents and ideas as inspiration for producing works. However, if one creative work has been inspired by or derived from another, the following questions arise:

- How much work and creative ability has been expended by each author/artist?
- Is the second work a reproduction of a substantial part of the first?
- Would an objective party perceive the second work to be a copy of the first?
- Can a "causal connection", whether conscious or subconscious, be established or set aside?

The combination of these and related factors will be determinative of any claim that the second work is an unlawful breach of copyright of the first, and will determine whether the second work is sufficiently original to attract copyright in its own right.

*James Carnie is the Principal, and Kara Wilton is a Solicitor at Clendons. Clendons is an Auckland based law firm, specialising in copyright and intellectual property issues. The firm is a sponsor of RINA.*

# VTF—RINA Prize 2007

The 2007 VTF-RINA Prize was awarded to Henry Alasdiar Donald and Joseph Reindler for their project **"A Study of the Aerodynamics of the Olympic Variant Tornado Class Catamaran".**

Joseph Reindler travelled to the UK in November and was presented with his award by Trevor Blakeley at RINA Headquarters in London.

Trevor Blakeley will be coming to New Zealand in February and will present Henry his award during his visit here.

Trevor hopes that he has the opportunity to meet with members of the Division and the Division Council, to update them on what the Institution is doing and to hear their views on what it should be doing.

## NZ Division Library

Don't forget our library is now housed at the National Maritime Museum.

## Forthcoming events

As it is the holiday season we have no events scheduled for January.

Please watch your **Inbox** for the latest events listings. If you do not receive email please pass on your details to to the division and we will ensure you hear about our talks.

The New Zealand Naval Architect is published quarterly.

All correspondence and advertising should be sent to:

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