Bengt Blendulf

Bengt Blendulf is president/principal lecturer of EduPro US, Inc.Educated in Sweden, he moved to the United States in 1974 to start a subsidiary for a Swedish fastener manufacturer. Bengt also served for eight years on the faculty in the College of Engineering and Science at Clemson University. Since 1997 he (EduPro) teaches highly rated courses in Fastener Technology and Bolted/Screwed Joint Design in the U.S., Canada, Mexico, Europe, Asia and India, for engineers and other fastener professionals. Bengt was the chairman of ASTM F16.96 Bolting Technology from 1996 to 2006. In 2006 he received the Fred F. Weingruber award from ASTM for "his efforts to promote and develop standards for the fastener industry." He is the author of an extensive lecture book as well as over 100 technical papers and articles. His business address is: EduPro US, Inc., PO Box 232, Alameda, CA 94501; phone 510-316-3234; email: bengt@edupro.us; web: www.edupro.us.

DESIGN GUIDELINES & SOFTWARE DEVELOPMENT

The academic process of educating engineering students in the art of bolted/screwed joint design has been (and still is) mostly inadequate due to lack of good and up-to-date text books and teacher enthusiasm. The engineering societies have done a good job in developing the necessary standards for the fasteners used in the joints, but not been much involved in how to actually use them. The exceptions are the standards where codes are necessary for public and personal safety, like structural bolting (ASTM) and pressure vessels (ASME). But, for those of us not involved in building bridges, skyscrapers or boilers, very limited and useful design information has been coming from these organizations.

ASTM F16.96 Bolting Technology

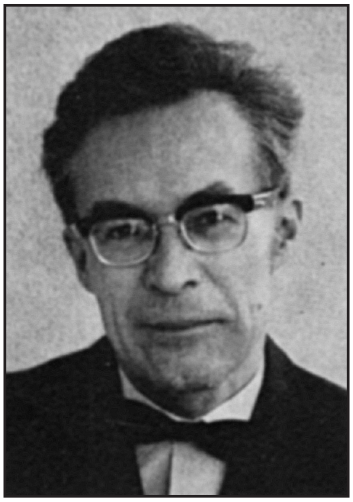
In 1986, a group of about 15 engineers (writer included) met at the United Engineering Center in New York to establish what was becoming the Bolting Technology Council, BTC. The initiator and first chairman of BTC was John Bickford, who served in this capacity for 10 years. I was the chairman for the next 10 years, and Joseph Barron took over 2006.

The purpose of BTC was to develop real and useful guidelines for the design of bolted and screwed joints. Eventually, BTC joined up with ASTM's F16 Fastener Committee as subcommittee F16.96 Bolting Technology.

Short history of joint design

During the mid 19th century, designers generally sized up bolts on the basis of an external work load divided by the smallest cross section of the bolt, typically the minor (root) thread diameter. The quotient had to be equal to or less than the bolts tensile strength divided by a chosen (often guessed) safety factor. From about 1870 to the turn of the century, investigations added knowledge about the influence of alternating loads, tolerable stresses, eccentric loading, residual clamping loads, multi-axes load conditions and much more. The RŒtscher joint diagram from 1927 combined these factors to become the universal basis for joint calculations until present time.

Since WWII, major developments in fasteners and their applications have followed two main paths. The absolute majority of all new fastener products and fastening systems has been of US origin. At the same time, the Europeans have directed most of their efforts toward developing systematic calculation methods for bolted/screwed joints. Two names of leaders in this field (both German) stand out to me as being particularly exceptional: Gerhard H. Junker, researcher and Technical Director for SPS Technologies in Germany and Karl-Heinz Kübler, Prof.Dr.-Ing.habil, researcher for Bulten in Sweden.



I had the privilege of having Dr. Kübler as one of my instructors when joining Bulten in 1966. He could explain the complex interaction of spring rates, force applications and other influences better than any other person I have worked with during my entire journey in the fastener world. He was also a very soft spoken and kind person, who spoke with an accent but certainly did not think with an accent.

Enter VDI 2230

Both of these gentlemen participated in the group that developed the Guide Line VDI 2230 – Systematic Calculation of Highly Stressed Bolted Joints – published in 1977 by the German Society of Engineers (VDI).

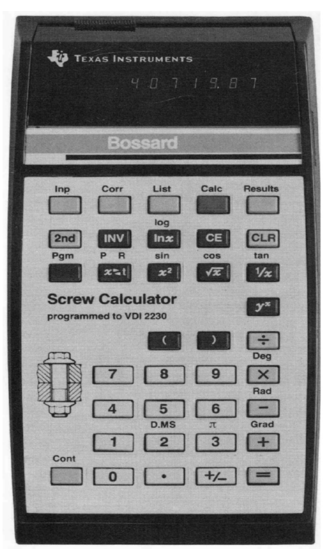
Over the past 3 decades, VDI 2230 has gradually become the basis for manufacturing industries all over the world. I proposed during one of the first meetings in the Bolting Technology Council that we (the US) should adopt this guide line instead of spending countless hours arriving to the same conclusions. We could simply translate it to English (with the OK from VDI of course), but my suggestion was not accepted by the majority of council members because it was not US made! We have since 1986 not been able to work up a similar guide line for ourselves. In the mean-time VDI 2230 now is published by VDI in both German and English!

As you may expect of a technical engineering document like this coming out of Germany after many years of preparation, it is not written on one single page. In fact, it is a rather extensive guide line, with a multitude of equations, tables, graphs plus a database for products, threads and materials. To use it manually is a challenge to anyone and also a rather time consuming activity.

Software Development

Due to the complexity of the VDI 2230 guide line, a project was initiated by Bossard in Switzerland (Jakob Kluser being greatly involved) and Dr.-Ing. Michael Galwelat at the Technical University of Berlin to develop a computation method utilizing a modified, programmable calculator. Texas Instrument in Zürich started working on a modification of their T-58 model to fit the program and the result was the Bossard Screw Calculator.

I got involved in this project to, among other things, do translations and work on a step-by-step manual to make the calculator as user-friendly as possible.



The Bossard Screw Calculator was easy to use: After data input, which could typically take 10 to 15 minutes, the calculator needed about 2 minutes to do the calculations and prepare the results and produce safety factors. This information had to be either written down on a specially prepared form by recalling one item after another, or printed out on a paper strip. If the designer did not like the initial results, he/she could then edit the input data (i.e. stronger fasteners, better tightening tool, etc.) and push the calculation button again for another 2 minute wait for the re-calculation.

Compared to today's micro-second calculations this seems like an eternity, but back in the early 1980's this was considered "lightning-quick". We also have to realize that compared to 6-8 hours of working VDI 2230 with a regular calculator or slide-rule, this was truly a revolution.

Acceptance

When I introduced the Bossard calculator/VDI 2230 in the United States in 1983 it was first met with a great deal of interest by design experts in the high-tech and auto industries. However, the interest did not result in the high sales volume we expected, in fact, it was a great disappointment. I got a lot of excuses mixed with the admiration of the project. One objection from one of our US auto makers was that it was "foreign" (even if they had engineers from their own German facilities involved in VDI), another was that it was "too complicated", their lawyers warned about possible misuse and lawsuits, etc.. I am known as a "stubborn old mule", but after a year of this up-hill battle I simply through in the towel and gave up on the project. I still have one of these museum pieces on my desk to remind me that I am not a good salesman.

The irony is that after 20 more years after I introduced the VDI 2230 in the US, it became the preferred design methodology for almost all of our high-tech and multi-national industries, including those who I tried to convince earlier.

In retrospect, had we waited a few more years until the PC's with floppy discs arrived more readily in front of all engineers, it may have given better results. Of course, the "fear-factor" would still be present.

Now, a quick leap into the future, a.k.a. TODAY.

VDI 2230 in the 21st Century

The VDI 2230 guide line and modern computer technology now make it possible to quickly find a way to design reliable and safe bolted/screwed joints even if they are complex. A few soft-ware programs have been introduced, all based somehow on the German document.

One of the first, and in my opinion still the superior, was the result of collaboration between Fritz Ruoss of Hexagon Industriesoftware GmbH in Germany (Fritz.Ruoss@hexagon.de) and Ralph Shoberg (rshoberg@rstechltd.com) of RS Technologies (now part of PCB) in Farmington Hills, MI. Their software is called SR1, S for Shoberg and R for Ruoss. Ralph had developed and patented the M-Alpha (moment/torque and angle) and F-Alpha (force and angle) graphics to augment the basic VDI 2230. This addition made SR1 a much more complete and useful tool both for joint design work and for performing audits.

For those of you (all of you I hope) who wish to study this in more detail, Ralph has written two recent articles in the Link Magazine (Spring 2011 34/2 and Fall 2011 34/4) that I strongly recommend that you read or re-read.

Now a Word or two of Caution

It is easy to get carried away with all the fancy micro-second capable calculation programs and colorful FEA pictures we have access to today. So, if we disconnect our brains and creative minds and just do the "thinking" with happy fingers on the key-board, we may burn these fingers and a lot more. Any good and reliable joint design must always start with considering things like:

*Joint Geometry
*Magnitude and direction of external forces
*Materials (corrosion, thermal expansions, etc.)
*Temperatures
*Tightening method
*Fastener choices
*Accessories
*and the list can be made a lot longer.

With today's higher demands on light-weight and high-strength designs, we must design our mechanical joints with more care and with much less guess-work. Using modern software and proven design guide lines like the VDI 2230 will be great supplements to our own abilities to think and to be creative.