

NEW ACCELERATOR BEAM CENTERLINE (ABC) PRODUCTION LINE AT VAREX IMAGING CORPORATION

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Abstract

In January 2017, Varian Medical Systems, Inc. (Varian)¹ completed a spin-off of its imaging components business into a new, stand-alone public company, Varex Imaging Corporation (Varex)². Varex is based in Salt Lake City, Utah, and is a leading innovator, developer, and manufacturer of X-ray imaging component solutions. As part of Varex's security and industrial business, based in Las Vegas, Nevada, Varex manufactures high-energy linear accelerators (Linacs). In May 2016, 8 months prior to Varian spinning off Varex, it acquired the assets of two small companies³ to add the distribution of betatrons and detector arrays as well as development of linear Accelerator Beam Centerlines (ABC) to Varex's capabilities. In the years since acquisition, Varex has moved ABC production from California to Salt Lake City, Utah and designed, produced, and tested several ABCs to meet or exceed the existing product specifications. A number of new products in the energy range of 1-20 MeV are under development for broad energy and dose rate regulation, as well as smooth and reliable operation, and are expected to be available for security, NDT, sterilization, intraoperative, and other applications.

NEW PRODUCT LINE AT VAREX

In January 2017, a new, stand-alone public company, Varex Imaging Corporation has been born. Varex is based in Salt Lake City, Utah, and is a leading innovator, developer, and manufacturer of X-ray imaging component solutions.

The SIP business in Las Vegas, Nevada is part of the Varex Imaging Corporation. Varian acquired the assets of two small companies to add ABC design and production capability to linear accelerator system production. ABC is one of the core elements of any linac, defining its performance in many ways, so bringing this design and production capability in house was a very strategic move for Varex.

Varex received a completed design of a new 12 MeV X-band accelerator model for intraoperative application, as part of the acquisition, and its prototype has already been fully tested by the key customer [1], meeting or exceeding all specification requirements; we secured a production contract with the same customer. The new RF structure

design and the ABC-12ER-X-E model was made 20% shorter compared to its predecessor [2, 3]. The first unit was designed by the author 25 years ago, and it successfully operated at a UCSF hospital and has been decommissioned recently. The new design permitted a substantial irradiator reduction while ensuring smooth, reliable operation, so important for the unique application in this emerging and growing niche market. As a result of the acquisition in 2016, Varex has also added distribution of betatrons and detector arrays to its business. The distribution contracts for the betatrons, produced by Foton LLC and detectors by Indicom LLC (both are Russian OEMs) are also strategically exclusive for the key security screening customers, known in the US and worldwide markets.

During the first couple years since the acquisition and to ensure a smooth transition, Varex continued production of the ABCs on premises of Bodycote facility in Fremont, CA. At the end of the calendar year 2017, we relocated guide production to the main plant in Salt Lake City, which has many of the similar key capabilities used for high voltage vacuum tube production. Presently, Varex has completed integration of ABC design and production at its Salt Lake Facility.

We have produced and tested several ABC prototypes in order to meet or exceed the existing SIP product specifications, and some ABC models have been released to production. We have established a pilot production line capable of producing up to 20 ABC units per year. Our pilot production line permits a complete "from A to Z" in-house ABC production. We prefer, however, to buy several tested and ready to install components, such as electron guns and RF-windows directly from other OEMs. All other work is done in-house. High-power testing is done at our SIP Division Las Vegas, but we will be adding two test cells in Salt Lake City during this and the next calendar years. We are quickly expanding and adding clean assembly rooms to our production capabilities in this and the next calendar years. The objective is to increase linac production capacity to 100-150 guides/year, in a mix of different models. The product marking at Varex follows its nomenclature, see Fig. 1. The designed ABCs key parameters for a variety of linacs are shown in a table shown in Table 1. Examples of our new developed products are shown in Figs. 2, 3 and 4.

1 - <https://www.varian.com/>

2 - <https://www.vareximaging.com/>

3- both Thought One LLC and Radmedex LLC have been dissolved in 2018 upon completion of the transition process

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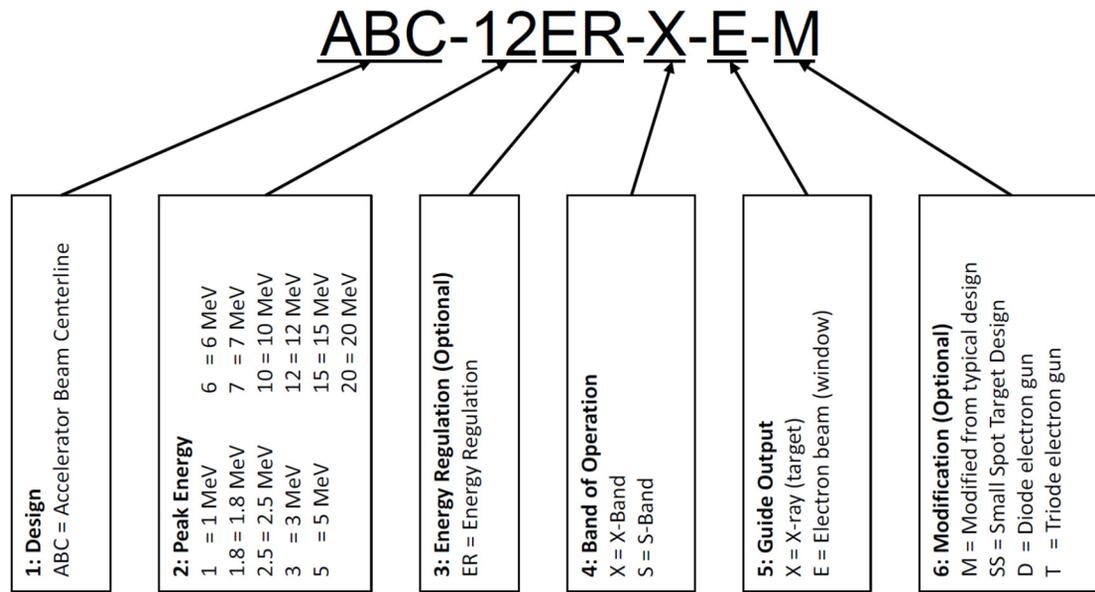


Figure 1: Accelerator Beam Centerline Nomenclature.

Table 1: Various ABC Are Enclosed in the Table Below, Data May Be Provided for Each Model Upon Request

Part Number	Model	Operating Energy Range, MeV	Max Dose Rate @ 1m From Tungsten Target	Electron Beam Current Peak, mA	Description
140439	ABC-3-S-X-D	1.7-3.9	500	0-310	For 3 MeV Linac, Diode or Triode E-Gun Options Fully Tested
145686	ABC-3-S-X-T	1.7-3.9	400	0-310	
137034	ABC-5-S-X-T	3.5-6.4	700	0-260	For 4 Or 5 MeV Linac, Triode E-Gun
145266	ABC-5-S-E-T	3.5-6.4	N/A	0-260	
139853	ABC-7ER-S-X	3.2-8.0	1300	0-280	For 6 Or 7 MeV Linac
145268	ABC-7ER-S-E	3.2-8.0	N/A	0-280	
145262	ABC-9-S-X	7.0-11.5	2500	N/A	For 9 MeV Linac, E-Beam Tested, Dose Rate Estimated, TBD
145261	ABC-9-S-E	7.0-11.5	N/A	0-75	
145269	ABC-10-S-E	10	N/A	230	For High Power E-Beam (15-20KW) 10 MeV Linac
146601	ABC-15-S-X	15	TBD	N/A	Replacements for Varian K-Series, 15-20 MeV, Design Data Only
146602	ABC-20-S-X	20	TBD	0-30	
142873	ABC1-X-X	0.9-1.3	10	0-150	Measured data with lower power magnetron at 300 kw peak
136813	ABC-1.8-X-X	1.8	14	0-100	
146603	ABC-2.5-X-E	1.5-2.9	100	0-100	Design data for higher power magnetron
145270	ABC-6-X-X	5-6.5	TBD	0-150	Design data for higher power magnetron
145271	ABC-6-X-E	5-6.5	N/A	0-150	
136775	ABC-12ER-X-E	4-12	N/A	10	Intraoperative application, mature product

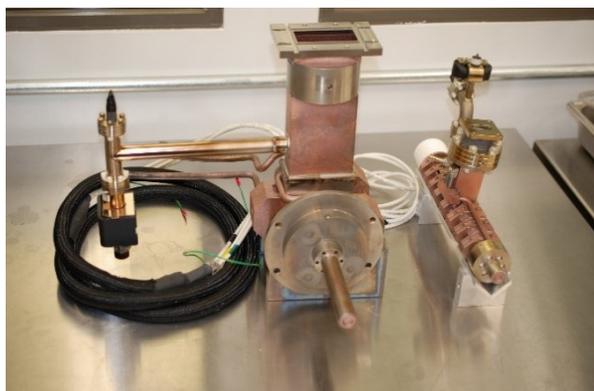


Figure 2: Fully assembled and ready for high power testing 3 MeV S-Band and 1.8 MeV X-Band ABC.



Figure 3: New 10 MeV S-Band ABC for high e-beam power applications.

CONCLUSION

In five years starting June 2016, we developed Accelerator Beam Centerlines (ABC) in a full usable range of its key parameters for our SIP “Imaging by Varex” linear accelerator systems and for third parties, starting from ground zero, we have established a pilot design and production line at Varex for up to 50 units/year, and currently expanding our capacity to 100-150 units/year. Varex now has full

ABC production and testing capability, which we expect to mature within the next 2-3 years.



Figure 4: One of our portable X-band ABC.

ACKNOWLEDGEMENTS

This work is a result and continuation of many pre-existing efforts [2-4], other work, made jointly with my mentors, superiors, peers, and direct reports, and I use this opportunity to remember those who passed and those who are still living, sincerely thank all for their knowledge and wisdom they shared with me, for their direct and indirect inputs throughout my 37-year career. In addition, I would like to thank Varex senior management for trusting me with this unprecedented challenge to provide leadership and set up a production line of a breath and scale comparable to Varian. The linac team we have put together at Varex is yet a small, but clearly a world-class team consisting of well-trained superb individuals, eager to continuously learn and capable of solving many future challenges.

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